# Manufacturing Skills Initiative

## A Report for
## *Work*Source – Greater Austin
## Area Workforce Board

**A Research Initiative of *Work*Source-Greater Austin Area Workforce Board**

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Finally, while we are grateful this abundant assistance, we want to remind the reader that the authors remain responsible for any errors of omission or commission in this report.

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# EXECUTIVE SUMMARY

In 2005, *Work*Source: the Greater Austin Workforce Development Board established the Critical Skills initiative to reinforce economic development efforts by better preparing residents for job opportunities being created. To oversee the initiative, a Critical Skills Task Force was established, composed of representatives from the Greater Austin Chamber of Commerce, industry, Austin Community College, the Austin Independent School District, Travis County, and Capital Area Council of Governments (CAPCOG). The main activities of the Critical Skills research are three-fold: (1) to identify industry clusters that are key targets of economic development efforts and emerging critical skills shortage occupations, (2) to determine the contributing factors and root causes of these emerging shortages, and (3) to recommend solutions. In other words, the goal of this initiative is to align regional workforce programs to provide a reliable supply of qualified job seekers to help prevent skill shortages from impeding economic development efforts.

Initially, the Critical Skills initiative focused on *biotechnology* and *wireless technologies*. Following up on the research, *Work*Source established or strengthened training programs in these areas at Austin Community College. In a second round of research beginning in 2006, attention was directed to clean energy industries, especially *photovoltaics* and to *advanced manufacturing*. In May 2007, the Critical Skills Task Force approved three topics in advanced manufacturing for further investigation: *semiconductor manufacturing*, *nanotechnology*, and *mechatronics*. The state of Texas had identified Semiconductors and Nanotechnology as key "sub-clusters" under *Advanced Technologies and Manufacturing*–one of the six major industry clusters targeted by the Texas State Cluster initiative.

The semiconductor industry is Austin's best-established manufacturing cluster, with chip design capabilities, suppliers, specialized service firms, customers and competitors located in the area. While Austin's semiconductor industry suffered a major drop in employment in 2001, employment has been recovering and the need for skilled operators and technicians is now on the rise. Semiconductor production alone accounted for more than a quarter of total manufacturing employment in Travis County in 2006.

A different situation exists with nanotechnology, mainly because it is still in an emerging stage. Although the major focus remains on research and development, nanotechnology has begun to come into commercial use. Nanotechnology promises new solutions for many of society's greatest technological needs, including sustainable energy sources, medical diagnosis and therapy, rapid advances in information technology, and exciting new applications in manufacturing.

Mechatronics is a multi-skilling approach to training that integrates knowledge of mechanical and electrical systems, with control systems and information technology. This technology holds potentially important implications for workforce preparation of technicians.

Both nanotechnology and mechatronics involve converging technologies with significant emerging applications across a wide range of industries.

The Overview chart beginning on the next page summarizes key findings from the study.

# Manufacturing Skills Initiative - Overview of Findings

| Semiconductors | Nanotechnology | Mechatronics |
|---|---|---|
| Background | | |
| Semiconductor industry is well established in Greater Austin, with chip design capabilities, manufacturing facilities, key customers, suppliers, staffing agencies, legal and other professional support, educational/research partners. | Nanotechnology is a convergent technology with applications in semiconductors and electronics, biotechnology and diagnosis, medical devices, and numerous other industries. | Mechatronics is a multi-skilling approach that integrates mechanical and electrical systems, control systems, and information technology. |
| Economic/Employment Factors and Job/Skills Outlook | | |
| Pool of skilled employees is drying up as recovery from downturn continues.<br><br>Prevalent use of “contingent” labor for low-skilled operator positions, so high turnover rates are “built in.”<br><br>Work in new fabs will require adding “emerging … skills and knowledge related to the new enterprise automation systems, their maintenance, and the ability to utilize vast amounts of information they provide.”<br><br>The Council for Contingent Workforce Development (CCWD) created a pilot program with manufacturers and staffing agencies to “transition” contingent workers who “time out” at one company to a new company without a break in employment.<br><br>Government data about skilled and unskilled employment is conflated.<br><br>Technicians have more stable employment and transferable skills. | A tremendous amount of buzz, but very little current employment at the technician level in Austin yet.<br><br>Uncertain when the jobs will emerge, or how many.<br><br>Skill needs for technicians mostly relate to applying electronics and/or biotechnology knowledge and skills at the nano level, and to familiarity and skill in maintaining equipment used for nanotechnology applications.<br><br>Knowledge of nanotechnology is best viewed as a supplement to a strong technical, scientific or engineering background. | TSTC-TFI Labor Market Study reports 39 Texas companies would hire 230 mechatronics technicians in next year and 400 over next 1-3 years.<br><br>Austin companies do not commonly use the term “mechatronics” so it is difficult to capture information on employment and practices.<br><br>Attempts to conduct local validation of the TSTC study findings of Texas manufacturing employers identified as “employing mechatronics principles” yielded few local responses.<br><br>One Central Texas firm reporting mechatronics in practice divided work between technicians (electro-mechanical) and engineers (software and control systems) - thus technicians were not expected to have or use full integrated mechatronics skill set. |

| Semiconductors | Nanotechnology | Mechatronics |
| --- | --- | --- |
| Training/Development/Preparation | | |
| *Austin Community College's Electronics and Advanced Technologies Program provides training that employers consider responsive to their needs.*<br><br>*The department's programs consist of core courses that form the foundation of the program, plus additional courses for a specialization. Students can earn multiple associates degrees by adding specializations without having to repeat the core courses.*<br><br>*ACC has stepped up its efforts to provide internships and scholarships by partnering with industry.*<br><br>*The Council for Contingent Workforce Development (CCWD), in collaboration with ACC, has been offering training to prepare contingent operators for technician positions, which provide better employment potential and stability, higher wages, and better benefits packages.* | *Universities and community colleges around the country have begun to establish academic programs related to nanotechnology. Some areas offer degree programs in nanotech, while others add a specialization connected to a broader emphasis on science, technology, or engineering. Most community college nanotech programs operate in partnership with a nearby 4-year university to leverage equipment and facilities.*<br><br>*UT-Austin offers a 12-hour certificate in a portfolio nanotechnology program for graduate students from a variety of technical majors.*<br><br>*UT's new Nano-Lab offers undergraduates the opportunity to work with an interdisciplinary team on a one-week research module on nanotechnology.*<br><br>*ACC has faculty familiar with nanotechnology and has partnered with SEMATECH in the Nanoscholar internship program.*<br><br>*ACC is exploring options to develop a nanotechnology program in collaboration with the Microelectronics Research Center at UT-Austin* | *Mechatronics is emerging in 4-year engineering colleges around the country at the undergraduate and graduate levels, including UT-Austin.*<br><br>*Programs are emerging in 2-year colleges as well, but more recently; most are started with funding from grants and industry support.*<br><br>*TSTC Harlingen has the only 2-year mechatronics technology program in Texas. It was funded by NSF grant.*<br><br>*Mechatronics cannot be taught as a series of independent specialties. The various disciplines must be integrated for students/workers to be able to use the systems together. Integrated learning can be achieved through classroom or workplace projects, sometimes forming teams of students with different specializations on an integrated project.*<br><br>*ACC offers the various specialties that are needed, but does not yet have a course or program/project for mechatronics integration.*<br><br>*ACC is interested in understanding from employers which mechatronics areas are most important, and how those specialty skills are integrated and applied in Central Texas workplaces.* |

| Semiconductors | Nanotechnology | Mechatronics |
| --- | --- | --- |
| Key Issues for Workforce Development | | |
| *ACC's program is underutilized-- operating at about 25% capacity.*<br><br>*The CCWD training program is also having difficulties attracting and retaining student/workers.*<br><br>*This problem is not unique to Austin.*<br><br>*Workers do not perceive a guaranteed (or even highly likely) payoff for skills development in the semiconductor field because of the prevalent use of contingent labor and reduced frequency of converting contingent workers into regular employees. Since there are a number of contingent operators who previously worked in technical positions before the downturn, concerns about the economic security of the industry inhibit commitment to training.* | *The very limited number of nanotechnology technician jobs – currently and immediately projected – means that it is difficult to "test out" training options.*<br><br>*There is considerable interest in nanotechnology, as evidenced by the competitive Nanoscholar internships. However, that nanoelectronics internship program did not have any explicit learning objectives related to nanotechnology, did not provide an initial orientation to nanotechnology, and did not evaluate the program on the basis of what students learned relevant to nanotechnology.*<br><br>*Nanoscholars found that the experience was especially helpful for learning about work and obtaining employment in the semiconductor industry.* | *Information on local employer needs is sorely lacking, particularly about whether and to what extent mechatronics integration is already happening in Central Texas, and what those applications, processes, and skills actually "look like" and require of technicians.*<br><br>*ACC stands ready to develop responsive mechatronics training options, but cannot do so without input from employers about how these needs play out.* |

| Semiconductors | Nanotechnology | Mechatronics |
|---|---|---|
| Recommendations Going Forward | | |
| Recommendations on Council on Contingent Workforce Development Program<br>1. Communicate clearly — and regularly — about the program, and address worker questions and concerns.<br>2. Show workers that there is a payoff for skill development.<br>3. Improve on-the-job training and performance reviews. Establish a special experiential learning track on the job for participants in the program to enhance learning and help motivate them.<br>4. Provide tutoring, monitoring career development, and follow up activities to help assure that worker/students who start the program complete successfully.<br>5. Consider ways to implement progressive wage increases as skills improve.<br>6. Continue and increase ACC's involvement in presenting the program to potential participants.<br>7. Continue to refine the program design to improve access. Persist in commitment.<br>8 . Expand the contingent workforce development model beyond the semiconductor cluster into a broader selection of advanced manufacturing firms that use contingent workers.<br>9. Identify transferable skills needed by technicians across Austin's advanced manufacturing firms and design on-the-job learning and certification in those skills. This will require securing input from a variety of firms.<br>10. Create an organizational structure within the staffing industry capable of managing the contingent workforce development model, with input and support from client manufacturers.<br><br>Additional Recommendations<br>• Ask all major semiconductor employers to partner with WorkSource by providing data on contingent and employed operators and technicians on an ongoing basis. Obtain agreement from the firms to provide this information annually or bi-annually.<br>• Ask incoming students in the Electronics and Advanced Technology program about the source of their interest, what attracted them to the field, how they became aware of job opportunities, and their suggestions for outreach to other potential participants.<br>• When conducting outreach to high schools, distribute brief (anonymous) surveys of students to learn their impressions about career opportunities in the field and the training available.<br>• Use the information to improve outreach, program design, and to provide information to employers that would help to attract a larger pool of qualified candidates. | Our recommendations for nanotechnology follow **two key objectives:**<br>(a) Introduce nanotechnology to a wider audience, including high school teachers and students<br>(b) Add nanotechnology instruction as a supplement to existing technology and science programs.<br>If continued, Nanoscholar internships could be modified to provide more explicit focus on nanotechnology while continuing a broader emphasis on semiconductor industry.<br>➢ Provide all nanoscholars an introduction to nanotechnology<br>➢ Establish learning objectives related to nanotechnology,<br>➢ Include nanotechnology as part of the program's evaluation criteria.<br><br>ACC should pursue opportunities to–<br>• Collaborate with SEMATECH and the University of Texas at Austin to establish a nanotechnology initiative.<br>• Establish an introductory course on Nanotechnology and its Applications.<br>• Offer introductory nanotechnology course to reach high school teachers and students as part of a broader program of high school outreach.<br>• Build examples from nanotechnology into ACC's existing science and technology courses.<br>• Develop an interdisciplinary module focused on nanotechnology and make available as a "capstone" experience for students nearing completion of a program in related technologies or natural sciences<br>• Add an eighth specialization to the ACC Electronics curriculum with a sequence of courses in nanotechnology as the labor market develops for electronics technicians with knowledge of nanotechnology | Determine if there are other avenues or industry partnerships that could be explored to obtain the needed information about mechatronics.<br>• Task Force members – perhaps with ACC and the Chamber in the lead, in partnership with WorkSource - could jointly sponsor an information session on mechatronics and how other communities are responding.<br>• Representatives who come to the session could be asked to respond to the Mechatronics Skills survey and further assessment could be made about how to determine clear channels of communication between companies where mechatronics practices are emerging, and training providers such as ACC that want to be proactive with program development. |

# INTRODUCTION TO THE *WORK*SOURCE CRITICAL SKILLS INITIATIVE

## Background and Objectives

In 2004, *Work*Source - Greater Austin Area Workforce Board began the Critical Skills initiative to better align the workforce development system with economic development efforts in Austin with the goal of improving both. The effort aimed to reinforce economic development in the region by better preparing residents for job opportunities being created.

Both Texas state officials and the Greater Austin Chamber of Commerce (GACC) have embraced the concept of cluster-driven economic development. Both viewed industry clusters as "economic drivers" of vibrant, sustainable, prosperous communities. The modern concept of industry clustering was popularized by Michael Porter of Harvard's Business School. In order to use cluster as a focus of analysis and policy, a cluster must be defined clearly. But the criteria for clusters have proven to be very difficult to pin down. There are as many definitions as there are types of organizations using the term (Rosenfeld, 1995). Jacobs and DeMan (1996, p. 425) argue that there is no single correct definition of the cluster concept; different dimensions are of different interest.

### *Overview of Texas State Economic Development Efforts*

Encouraged by reports such as Ray Perryman's *Texas, Our Texas* that recommended "focused industrial recruitment" (Perryman 2002) and the research by Michael Porter on economic clusters, the Texas Legislature in 2003 passed S.B. 275, which authorized an industry cluster-based economic development initiative. The resulting *Governor's Cluster Initiative* staffed by the Texas Workforce Commission, sought to identify key economic clusters, which held special potential for the State. The result was the identification of six broad industry clusters, which were considered to be "engines of the Texas economy." They included the following industry clusters:

- Advanced technologies and manufacturing
- Aerospace and defense
- Biotechnology and life sciences
- Energy
- Computer and information technology
- Petroleum refining and chemical products

To develop an economic development strategy, a statewide cluster group for each area was established in 2005, composed of a committee of industry representatives and experts in each of the six industry clusters. To help staff the cluster groups, the state hired consultants and utilized the Texas Workforce Commission. The cluster groups conducted forums in major Texas areas (Houston, Dallas, Austin, San Antonio, El Paso, and for selected clusters, the Rio Grande Valley). The forums produced a SWOT (strengths, weaknesses, opportunities, threats) analysis in each area and targeted cluster. Findings from the forums were then combined into a statewide SWOT analysis. Each cluster group produced a cluster assessment report to Governor Rick Perry with policy recommendations (For these reports, see http://www.twc.state.tx.us/news/ticluster.html).

In a separate but related effort, called the *Texas Technology Initiative* or the "State Strategy on Advanced Technology" (SSAT), teams of experts from across Texas were established for six advanced technologies underlying the clusters:

- Advanced Energy Application
- Biotechnology
- Software Technology/Wireless
- Micro-Electrical-Mechanical Systems (MEMS)
- Nanotechnology
- Semiconductors

As shown in the Table 1, there is considerable overlap in the industry targets of these two Texas state initiatives.

### *Economic Development Targets in Austin*

The economic development efforts of the Greater Austin Chamber of Commerce have been focused by two strategic planning studies, which were commissioned and published by the Chamber in 1985 and in 1998 (SRI International, 1985 and ICF Kaiser International Economic Strategy Group, 1998). These reports outlined options available to Austin. The conclusions reached by these studies helped to achieve widespread consensus and provide direction to Austin's business community.

Aiming to repeat their earlier success, in 2003 in the middle of a downturn, the Greater Austin Chamber conducted a special "Opportunity Austin" fund-raising campaign, which yielded pledges of $11 million for economic development. GACC hired Market Street Services, Inc. of Atlanta, Georgia to help identify the clusters (Market Street Services, 2003). In 2004, GACC embarked on a five-year plan targeting nine economic clusters:

1. Automotive Manufacturing
2. Biosciences, including biomedical, and pharmaceutical products
3. Product Manufacturing
4. Wireless Technology
5. Transportation and Logistics
6. Computer Software
7. Clean Energy
8. Semiconductors
9. Digital Media

Although the GACC and the State of Texas use different terms and define the clusters differently, there is considerable overlap among their targeted industries. Texas generally has defined the clusters more broadly than does the Austin Chamber. For example, the Texas cluster *computer and information technology* encompasses the GACC targets of *computer software*, *wireless technology*, and *digital media* as well as part of the category *semiconductors*. Likewise, the State category *advanced technologies and manufacturing* includes GACC targets *automotive manufacturing*, *product manufacturing*, and a portion of *semiconductors*. Finally, the Texas State category *energy* includes *clean energy* (See the side-by-side comparison in Table 1).

**Table 1. Target Industry Cluster Comparisons:**
**Austin and State of Texas**

| 2004 GACC Opportunity Austin Industry Clusters | Texas Industry Clusters | SSAT Underlying Technologies |
|---|---|---|
| Biomedical | Biotechnology & Life Sciences | Biotechnology |
| | Aerospace & Defense | |
| Automotive Manufacturing | Advanced Manufacturing | |
| *Product Manufacturing* | | |
| | | Micro-Electrical-Mechanical Systems (MEMS) |
| | | Nanotechnology |
| Semiconductors | Information & Computer Technology | Semiconductors |
| Wireless Technology | | Wireless/ Software Technology |
| Computer Software | | |
| Digital Media | | |
| *Transportation & Logistics* | | |
| Clean Energy | Energy | Advanced Energy Applications |
| | Petroleum Refining & Chemical Products | |

Since 2004, the Austin Chamber has effectively reduced its focus from nine to seven clusters, eliminating a standalone focus on transportation and logistics and product manufacturing (designated above in italics). Although the Chamber remains interested in strong transportation and logistics systems to support economic development, this cluster is no longer considered a targeted cluster itself. Also, the Chamber is no longer pursuing or addressing "product manufacturing" as an overarching "cluster"; rather, manufacturing is pursued as parts of the other clusters (e.g., biosciences, wireless, semiconductors, etc.) by the staff assigned to that cluster.

During summer 2007, the GACC began a process of reviewing and selecting its target industry clusters for a second "Opportunity Austin" campaign to finance economic development activities over the next five years. The Chamber again hired Market Street of Atlanta to prepare a series of reports to help determine appropriate industry targets.

### *The Critical Skills Project 2005*

Since the purpose of the Critical Skills initiative was to better align the workforce development system with economic development efforts, the criteria for selecting the first industries to be studied under the 2005 initiative focused on two major factors: labor market suitability of the industry cluster for attention by *Work*Source and the potential for industry engagement. Labor market suitability included five elements:

Critical to economic development. Is the industry cluster targeted by the Greater Austin Chamber of Commerce or by the State of Texas?

Strong employment demand. Are employers hiring and do they have ongoing openings?

Experiencing shortages in key occupations. Do demand figures show shortages? Are significant numbers of jobs involved?

Good earnings, benefits and opportunities for advancement. Do the positions pay at least the minimum standards set by *Work*Source, offer benefits, and provide opportunities for advancement?

Appropriate for targeting by the workforce system. Are there multiple entry points below a 4-year college degree for skilled, trained workers?

The potential for industry engagement was assessed on the basis of three elements:

Cluster group in existence locally. Do industry representatives from this cluster have an association or other active group so that initial outreach and analysis can be conducted through existing channels?

Recognized need by the industry cluster. Do employers in the cluster acknowledge shortages in critical skills occupations, although they may not be aware of the scope of the problem sector-wide? How have they demonstrated their recognition of need?

Willingness to contribute to solutions. Are at least some employers willing to participate in the project from the beginning, to share information for analysis, and to help define and contribute to development of solutions? Who will work with us? What is their level of commitment?

Using these criteria to examine each of the Chamber's nine targeted industry clusters, Ray Marshall Center researchers determined that **biotechnology** and **wireless technology** held the most promise for research (Glover et al., 2005a). The Critical Skills Task Force and the *Work*Source Employment Initiatives Committee agreed.

Thus, the initial Critical Skills research was conducted on biotechnology and wireless technology. Researchers made several recommendations (See Glover et al., 2005b and 2005c). Following through on recommendations made by the research team, *Work*Source took several actions:

- Through a grant from the Texas Workforce Commission, WorkSource established a project to expand and strengthen Austin Community College programs related to biotechnology, adding courses in bioinstrumentation and molecular diagnostics.
- *Work*Source funded a project to establish a training program in wireless technology in the Continuing Education Division at Austin Community College.
- *Work*Source began organizing its list of targeted occupations by industry, giving greater attention to occupations in industries targeted by economic development.

Having put in place training to address needs in biotechnology and wireless technology, *Work*Source decided to sponsor research on other industry sectors targeted by the Austin Chamber. In order to support clean energy objectives, *Work*Source sponsored research on labor market needs for **photovoltaic systems**. Since three of the nine original industry clusters targeted by the GACC were in manufacturing and several other clusters had elements of manufacturing, *Work*Source also chose **manufacturing** for study. *Work*Source added two occupations in manufacturing to its list of targeted occupations—*Electronic Assemblers and Fabricators* and *Semiconductor Processors*.

In November 2006, *Work*Source initiated a competition for research on automotive, product and semiconductor manufacturing. This request led to the Manufacturing Skills Initiative.

# THE *WORK*SOURCE MANUFACTURING SKILLS INITIATIVE

## Manufacturing: An Attractive Target for Economic Development

Manufacturing is a popular target of economic development efforts; it is considered a "primary industry" in economic development parlance. The economic development community has long recognized manufacturing as a high value-added activity. Manufactured products are generally sold outside of the area, bringing income back to the area in return.

Manufacturing has a central role in the economic development targeting of both the State of Texas and the GACC. Three of the nine industry sectors initially chosen by the GACC as economic development targets were in manufacturing—automotive components manufacturing, semiconductors, and products manufacturing. GACC has identified a base of manufacturing firms located in Greater Austin. Manufacturing overlaps with several other targeted industry clusters, including production of biomedical and pharmaceutical products and medical devices, wireless technology equipment, etc. No Chamber staff is specifically assigned to manufacturing as a category/cluster unto itself; rather the staff member assigned to each cluster works on attracting and expanding manufacturing firms within that cluster.

While it is clear why manufacturing is an attractive target for economic development, it is less clear why it should become a target for workforce development, in view of general trends in manufacturing employment. Nationally, employment in manufacturing has been declining for decades both absolutely and as a percent of the total employed workforce. This trend is continuing as many lower skilled manufacturing jobs are eliminated through conversion to lean manufacturing practices, replaced by automation, or outsourced to China, India or other countries where wage levels are lower. As an implication of all these trends, manufacturing jobs remaining in the U.S. will require higher skill levels.

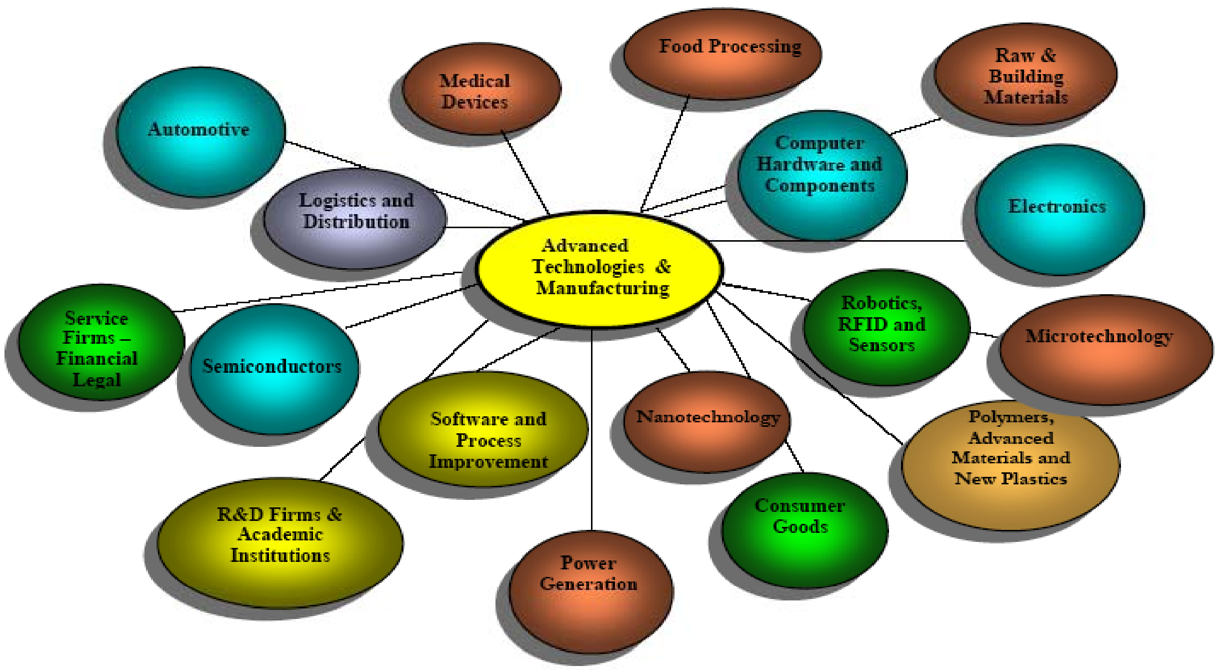
It has long been recognized that maintaining manufacturing is critically important for the American economy (Cohen and Zysman, 1987). In Texas, manufacturing still accounted for 12.33 percent of total state Gross Domestic Product (GDP) in 2005. Indeed, among all states in the U.S., Texas had the second largest total of Gross Domestic Product (GDP) generated through manufacturing – behind only California ($IC^2$, 2006). At this point, the types of manufacturing jobs most likely to remain and expand in the United States are in advanced manufacturing.

## Focus on Advanced Manufacturing

At the state level, "Advanced Technologies and Manufacturing" is one of six major clusters targeted by the Governor's Cluster initiative. In addition, semiconductors, nanotechnology, and micro-electrical-mechanical systems (MEMS) have been targeted as underlying technologies in the State Strategy on Advanced Technology. All these advanced technologies are important to the future of American manufacturing.

There are various definitions of Advanced Manufacturing. Some define it by the type of product produced, others by the nature of the manufacturing process, and others by the proportion of revenue the industry spends on research and development. As shown in Figure 1, the state of Texas included m any types of manufacturing and aspects of the manufacturing process under its cluster “Advanced Technologies and Manufacturing.”

**Figure 1. Advanced Technologies and Manufacturing Cluster As Identified by the State of Texas**




Source: Texas Workforce Commission, Advanced Technologies and Manufacturing Cluster Assessment August 2005, p. 12

Austin has a strong high-tech manufacturing sector, which qualifies as “Advanced Manufacturing” under any definition. At the end of 2006, there were 841 manufacturing establishments in Travis County (See Table 2).

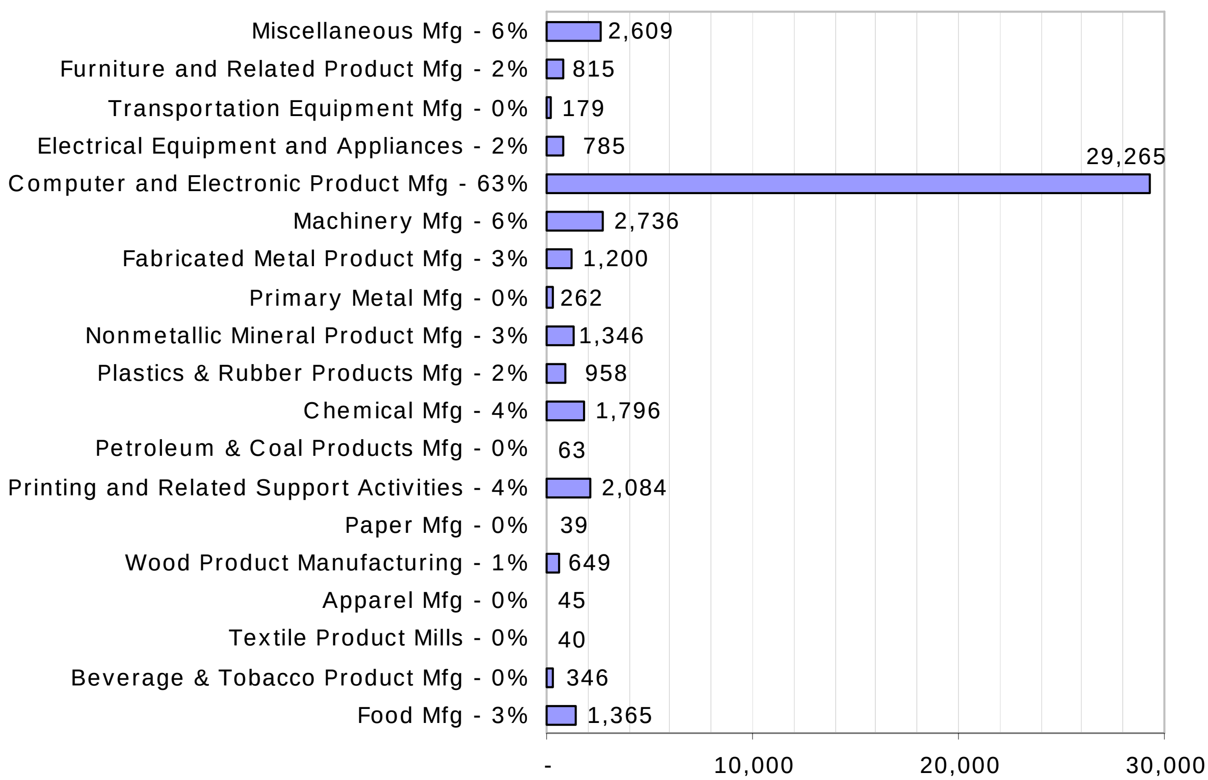
As illustrated in Figure 2, employment was heavily concentrated *Computer and Electronic Products Manufacturing (NAICS Code 334)*. Within this category*, Semiconductor and other electronic components* manufacturing (NAICS Code 33441) accounted for more than half of the employment.

**Table 2. Manufacturing Employment in Travis County, 4th Quarter 2006: By Industry**

| NAICS (3-digit) | 2007 NAICS US Title | Employment 2006 | % | # of Establish-ments | % |
|---|---|---|---|---|---|
| 311 | Food Mfg | 1,365 | 3% | 59 | 7% |
| 312 | Beverage & Tobacco Product Mfg | 346 | 0% | 14 | 2% |
| 314 | Textile Product Mills | 40 | 0% | 10 | 1% |
| 315 | Apparel Mfg | 45 | 0% | 9 | 1% |
| 321 | Wood Product Mfg | 649 | 1% | 17 | 2% |
| 322 | Paper Mfg | 39 | 0% | 5 | 1% |
| 323 | Printing and Related Support Activities | 2,084 | 4% | 155 | 18% |
| 324 | Petroleum & Coal Products Mfg | 63 | 0% | 3 | 1% |
| 325 | Chemical Manufacturing | 1,796 | 4% | 28 | 3% |
| 326 | Plastics & Rubber Products Mfg | 958 | 2% | 21 | 2% |
| 327 | Nonmetallic Mineral Product Mfg | 1,346 | 3% | 42 | 5% |
| 331 | Primary Metal Mfg | 262 | 0% | 11 | 1% |
| 332 | Fabricated Metal Product Mfg | 1,200 | 3% | 86 | 10% |
| 333 | Machinery Mfg | 2,736 | 6% | 46 | 5% |
| 334 | Computer and Electronic Product Mfg | 29,265 | 63% | 147 | 17% |
| 335 | Electrical Equipment and Appliances | 785 | 2% | 22 | 3% |
| 336 | Transportation Equipment Mfg | 179 | 0% | 14 | 2% |
| 337 | Furniture and Related Product Mfg | 815 | 2% | 49 | 6% |
| 339 | Miscellaneous Mfg | 2,609 | 6% | 101 | 12% |
| | **TOTAL** | **46,582** | **100%** | **841** | **100%** |

Data specifically for the Capital Area Workforce Development Area (Travis County). Retrieved May 4, 2007. Annual Average Employment (in number) and Establishments by industry for the 4th Quarter in 2006; latest data available to date. Source: Texas Workforce Commission (LMI) TRACER, http://www.tracer2.com/cgi/dataanalysis/industryReport.asp?menuchoice=industry

**Figure 2. Manufacturing Employment in Travis County, 4th Quarter 2006: By Industry**




Data specifically for the Capital Area Workforce Development Area (Travis County). Retrieved May 4, 2007.
Source: Texas Workforce Commission (LMI) TRACER,
http://www.tracer2.com/cgi/dataanalysis/industryReport.asp?menuchoice=industry

## Selecting Manufacturing Industries for Study – Process and Recommendations

Our initial task was to select clusters or sub-clusters within manufacturing for more in-depth research on Critical Skill needs linked to economic development.

Our analysis of candidate manufacturing industries began with a check on the economic development targets and activities of the GACC and the State of Texas, along with a review of relevant literature. We contacted economic development staff at the Texas Workforce Commission, obtained documents, support materials and reports from consultants to GACC and the State of Texas, and reviewed relevant activities and initiatives currently underway in Austin, as well as reports on the Austin economy, and available labor market information and employment trends for each of the candidate industry clusters.

Our background research on each of Austin's identified manufacturing industry clusters included obtaining information on Austin-area firms, industry reports, and internet-based materials regarding how other areas had approached clusters in the same industries. We conducted interviews by telephone and in person with an initial set of industry, education and training, and intermediary informants.

Through our research and discussions, we determined several possible approaches to identifying, defining, and assessing clusters in Austin we believed would provide the strongest potential match for the goals of *Work*Source's Manufacturing Skills Initiative. The following three approaches have particular relevance for manufacturing: (a) by industry sector, (b) by occupation, and (c) by technology or technological process.

The RMC research team recommended a hybrid approach to selection, rather than selecting only by sector, occupation, or process. While some crossover would be likely, the hybrid approach would also be more likely to reveal broader applications across industries or recognize the importance of emerging technologies that cross industries or "sectors," and their impact on economic development. In addition, training providers tend to respond to needs in a cluster by identifying the core knowledge and skills, which are dependent on a combination of the industry, the occupation, and the technologies and processes in use.

The four Advanced Technologies and Manufacturing "sub-clusters" defined by the Texas State Industry Cluster initiative are:

1. Automotive Manufacturing
2. Semiconductor Manufacturing
3. Nanotechnology and Materials
4. Micro-Electrical-Mechanical Systems (MEMS)

The last three were among the six advanced technologies identified under the Texas State Strategy on Advanced Technology (SSAT).

Based on our initial findings, the RMC research team recommended investigating new models for workforce development in Semiconductor Manufacturing, as well as the implications of Nanotechnology (including MEMS as appropriate and feasible), and Mechatronics for the workforce preparation of manufacturing technicians.

**Semiconductor manufacturing** is Austin's best-established manufacturing cluster, with design capabilities, suppliers, specialized service firms, customers and competitors located in the area. The semiconductor cluster has experienced significant fluctuations in employment with occasional occupational and skill shortages associated with high demand for operators and technicians. The largest semiconductor employers in the area have begun managing labor costs associated with these economic fluctuations by contracting with temporary staffing agencies for operators, resulting in a substantial "contingent" or "contract" workforce. While contingent staffing has resolved some problems, it has brought others. A new Council on Contingent Workforce Development was formed in February 2007 to try to introduce collaboration and long-term planning among key semiconductor employers and their staffing agencies in the industry, offering promising possibilities for study with significant implications for improving the "pipeline" and workforce training.

**Nanotechnology** is the science and technology of the very small. Through nanotechnology materials can be manipulated with precision at the atomic or molecular level. Nanotechnology is often regarded as the next basic technology to follow Information Technology and Biotechnology. Nanotechnology promises new solutions for many of society's greatest technological needs, including sustainable energy sources and medical diagnosis and therapy. Nanotechnology is converging with semiconductors now that semiconductors are produced at the nanoscale and chip-etching equipment can be adapted for nanodevices with medical and other applications (Ladendorf, December 9, 2007). Nanotechnology will bring rapid advances in information technology, and new approaches to manufacturing. Nanotechnology is driving the research agenda in many areas of science and engineering. Further, nanotechnology is the focus of major new R & D funding from government agencies and the private sector.

As Paul Barbara of the University of Texas explains:

> "It is widely believed that nanotechnology will have an enormous impact on industrial technologies in such diverse areas as medicine, electronics, computers, bio-medical engineering and biotechnology. For example new "nano-bio-electronic materials" are being developed for computers of the future and for chemical and biological sensors that will dramatically revolutionize medical care and bring a new level of safety and efficiency to manufacturing. Nanotechnology will revolutionize material science, producing inexpensive materials with extraordinary properties, such as super-strong materials for manufacturing, bright-emitting materials for television and computer displays, and much more." (2001, p. 1)

Nanotechnology is widely proclaimed as "the next big thing" with an economic impact comparable to the introduction of the steam engine or the computer. Hefty claims are made for the revenue and employment it will generate in the near-to moderate-term future. The National Science Foundation forecasts that nanotechnology will be a $15 trillion business employing more than a million workers. Austin is well known as a center of nanotechnology. The state of Texas has identified nanotechnology as a key strength and opportunity for Austin. The University of Texas is becoming a major research institution for nanotechnology. SCTC Technologies is acquiring SEMATECH's Advanced Technology Development (ADTF) and intends to equip it for contract research on nanotechnology projects. Our search for firms in Austin in May 2007 found a dozen active for-profit companies working in nanotechnology. The list of the firms identified can be found in Appendix C of this report.

***Mechatronics*** is defined as "the synergistic combination of mechanical engineering, electronics, control systems, and computers." An Emerging Technology Brief prepared by Eliza Evans of the $IC^2$ Institute for the Emerging Technologies Program at Texas State Technical College in March 2006 illustrates why research on mechatronics is relevant for this project (See Table 3).

**Table 3. Summary of Conclusions and Recommendations from Texas State Technical College Emerging Technologies Brief on Mechatronics, March 2006**

| | | |
|---|---|---|
| **Recommendation** | **Detailed Analysis** | Mechatronics does not map to any particular trade or job category rather, it refers to a host of integrated skills that can be applied in a variety of job contexts. We recommend further study of the diversity of jobs that do or may require mechatronics skills, the particular knowledge, skills and abilities of specific jobs or job categories and the actual needs of Texas employers. |
| **Jobs** | **Moderate to High** | As many as 18,400 have some relation to mechatronics. |
| **Trends** | **Inconclusive** | A number of mechatronics programs have been recently established or are under development. An investigation of the relevance of these programs, and the skilled workers they produce to Texas employers is warranted. |
| **Timing** | **Good / promising** | A number of community colleges and four-year institutions have established mechatronics-related courses, themes and degrees over the last several years. |
| **CTC Relevance** | **High** | Mechatronics skills are increasingly relevant to the performance of job duties associated with skilled trades such as engineering technicians, mechanics and appliance repair and maintenance. |
| **Transportability** | **High** | Applicable to a number of job positions related to advanced manufacturing, advance package and equipment and vehicle maintenance and repair. |

Source: Eliza Evans, $IC^2$ Institute (2006)

In conclusion, semiconductor manufacturing is Austin's best-established manufacturing cluster. An examination into developing the skills of contingent workforce offers useful possibilities for study with implications for the skill "pipeline" to that industry. Research that investigates the underlying technologies of nanotechnology and mechatronics is likely to reveal broad applications across several advanced manufacturing industries, shed light on important emerging technologies that cross industries or sectors, and help to identify the core knowledge and skills in these areas which are dependent on a combination of the industry, the occupation, and the technologies and processes in use. Such information will be helpful to education and training providers in building curricula and programs to address emerging needs.

## American Manufacturing—Perceptions and Realities

Given all the media attention devoted to outsourcing and layoffs of manufacturing workers, most Americans would be surprised to learn that the U.S. continues to be the dominant manufacturing power in the world. Yet America produced fully one-quarter of the world's manufacturing output in 2006 – a proportion that has been fairly steady for several years.

There is certainly a lot of turmoil in American manufacturing. Factories are closing. Production is being outsourced to China, India and elsewhere. And there is no doubt that the labor force employed in manufacturing has been in long-term decline in both absolute and relative numbers. So how can be it that our output is increasing to maintain pace with rising world production?

The answer is found in increased productivity. American factories are producing more with fewer workers. To understand this reality and to see the future, one need only look at Austin's most recent factory scheduled to begin production in fall 2007—Samsung's new 300 mm semiconductor fab. The change to 300 mm involves more than simply using a larger silicon wafer. The 300 mm semiconductor manufacturing environment is an entirely different way of operating, as explained by Bob Simington of Intel:

> "The semiconductor manufacturing environment has evolved from one that was populated with self-contained tools utilizing robotics technology to one that is composed of large numbers of these tools interconnected by automated material handling systems (AMHS) and driven by a centralized manufacturing execution system (MES) in such a way to maximize factory throughput and output.
>
> This level of automation is referred to in Intel as the $7^{th}$ level" of automation or simply "level 7". A "level 7" automated factory is intended to run "lights out," with no human intervention in the normal operation of the factory. At Level 7, all work in progress is automatically dispatched to the appropriate tool at the appropriate time according to predefined rules. All tests are performed automatically and failed tests initiate recovery systems (including dispatching of maintenance technicians). Process monitors are embedded in the tools and statistical process control is monitored and maintained continuously. Appropriate actions are automatically initiated when control limits are violated. Human intervention is only required in this environment to change the operating rule, to change the "tags" associated with particular lots so that they are handled specially, to monitor the system for failures and safety violations and to perform maintenance.
>
> The skills required to work in such an environment consists of most of the skills required by the previous environment (i.e., 200 mm fabs) plus some emerging skills. These emerging skills are primarily skills and knowledge related to the new enterprise automation systems, their maintenance, and the ability to utilize vast amounts of information they provide."
>
> Bob Simington, Training Specialist at Intel Corporation
> As quoted in Lesiecki, *Skill Standards for Technicians in the Highly Automated Manufacturing Environment*, 2002, p. 39

This new environment requires fewer low skilled operators. Wafers will no longer be manually carried from toolset to toolset; they will move on automated conveyors. Working in such a highly automated environment demands increased skills and knowledge of all employees—but especially of maintenance technicians. To maintain the automated systems described above requires understanding of multiple crafts -- electronics, mechanics, control systems and software. This multi-craft combination of skills has long been known in Europe and Japan as "mechatronics." The term is coming into use in America, as well. Mechatronics is an interdisciplinary approach combining aspects of mechanical engineering, electrical engineering, computer engineering and information technology that is emerging in American engineering colleges. More recently, mechatronics programs are becoming established in community colleges.

Engineers are concerned with the design and construction of mechatronics systems that are more flexible and economical than automation of the past. As complex mechatronic systems become more prevalent in American factories, the demand will rise for workers who have the multiple skills to maintain them.

A second imminent change that will impact several manufacturing industries is the use of nanotechnology, our increasing scientific ability to understand and manipulate matter as the atomic and molecular scale both to improve existing products and create new ones. The drive to miniaturize has brought the semiconductor industry to nanoscale already. Austin's new Samsung plant previously mentioned has a capability to produce semiconductors in the 50-nanometer range.

This report examines the outlook for technician employment in Austin's advanced manufacturing sector. It discusses access, preparation and skill upgrading for technician jobs in the face of dramatic changes in both what is produced and how it is produced. Since fully one quarter of manufacturing employment in Austin is in the production of semiconductor industry, semiconductor manufacturing is a primary focus. The remaining sections of the report examine the implications for technicians of two convergent technologies expected to have major impacts on advanced manufacturing—nanotechnology and mechatronics.

# SEMICONDUCTOR MANUFACTURING

### Semiconductors: Austin's Best Established Industry Cluster

By any definition, the Greater Austin area continues to have a well-established, diversified semiconductor cluster. In 2006, the Greater Austin Chamber of Commerce identified 194 firms related to the semiconductor industry in the Austin area. This cluster includes several manufacturing fabrication facilities (Samsung, Freescale, Spansion, Cyprus Semiconductor, etc.), key customers (Dell, National Instruments, IBM), semiconductor chip design and R & D expertise (Intel, AMD, SigmaTel, IBM), key suppliers of semiconductor manufacturing equipment (Applied Materials and Tokyo Electron which are ranked #1 and #2 in the world, and others, such as Dupont Photomasks, etc.), industry groups (SEMATECH, SEMI), knowledgeable staffing agencies with established track records with specific client firms (Adecco with Applied Materials, Manpower with Freescale and Samsung, Volt with Spansion), attorneys specialized in the needs of the industry (patent applications, H-1b visa processing, etc.), conventions (such as the World Congress on Information Technology held in Austin in May 2006), and educational institutions (College of Engineering, The University of Texas at Austin; Department of Electronics and Advanced Technologies, Austin Community College; and the Department of Technology, Texas State University).

### Economic/Employment Trends and Job/Skills Outlook

Semiconductor manufacturing is a fast-moving industry with very short product life cycles. There are several diverse and growing markets for semiconductors (which include computer memory and RAM chips, cell phones, automobiles, appliances, etc.). Competing effectively in semiconductor markets requires agile companies with well-trained flexible workforces who are constantly upgrading their skills.

According the U.S. Bureau of Labor Statistics, nationwide employment is expected to decline in semiconductors due to increasing use of automation of fabrication plants, the movement toward lean manufacturing in this country, and competition from many new fabrication plants abroad. The most recent available projections for employment in Texas and in the Capital Area Workforce Development Area (i.e., Travis County) are shown in Table 4.

**Table 4 Employment Projections for the Semiconductor Industry 2004-2014**

| Semiconductor and Other Electronic Equipment (NAICS Code 3344) | Employment in 2004 | Projected Employment in 2014 | Change in Employment | Percentage Change |
|---|---|---|---|---|
| Texas | 51,850 | 49,000 | (2,850) | (5.1%) |
| Capital Area WDA | 14,400 | 13,200 | (1,200) | (8.0%) |

Source: Texas Workforce Commission, Labor Market Information (www.tracer2.com)

These projections are especially inaccurate in the Austin area for at least two major reasons: (1) They do not take into account the industry's use of contingent workers (which are counted under the separate NAICS classification "employment services"; and

(2) The projections were made prior to Samsung's 2006 decision to build a new 300 mm fabrication facility in Austin. Indeed, average employment in Semiconductor and Other Electronic Equipment in Travis County during the 4th quarter of 2006, was 15,647—an increase of 1,247 employees (or 8.7 percent) over the 2004 level (Texas Workforce Commission, Texas Labor Market Information, www.tracer2.com).

With Samsung's decision to build a new-generation 300 mm fab in Austin, workforce issues are becoming prominent again. Semiconductor manufacturing employment in Austin has rebounded from its major decline in 2001. Over the past year, Samsung has been hiring technicians and senior operators in preparation for start up of its new 300 mm fab. Some of these are experienced workers from other semiconductor plants in the area. These fabs have had to find replacements. The pool of skilled technicians with experience in semiconductor manufacturing has begun to dry up.

While actual job titles vary from employer to employer, most semiconductor manufacturers producing in Austin have both operators (entry-level workers without technical preparation) and technicians, who are hired based on electronics skills and knowledge, and sometimes requiring an Associates degree. Typical job titles include Wafer Fab Operator, Microelectronics Assembly Operator, Wafer Fab Technician, and Manufacturing Technician. There is a general trend toward higher skill requirements, reflected in the lower ratio of operators to technicians hired in Samsung's new generation fab. In newer fabs, automation eliminates many operator functions; for example, wafers are moved around the plant through robotic equipment rather than manually. The result is need for fewer operators. However, other semiconductor manufacturers using older fabs have considered the opposite approach, replacing some technician positions with operator positions depending on the skill needs in that area of production.

Operator positions require lower skill levels and less technical knowledge than technicians. Yet the U.S. Bureau of Labor Statistics (BLS) consolidates both into a single occupational category entitled "semiconductor processors." In addition, the use of contingent workers masks the industrial classification of workers; for example, contingent workers are reported as "employment services" in government statistics, rather than by the industries they are assigned to work. As a result, monitoring the relative numbers of operators and technicians employed cannot be accomplished through the data routinely collected and reported through government agencies.

Although Austin has experienced an upward trend in semiconductor employment during the past two years, there is variation around the trend. There continues to be some instability of employment among semiconductor manufacturers—especially for operators. The industry in Austin continues to experience layoffs, for example, the undisclosed number of workers laid off at SEMATECH's Advanced Technology Development Facility (ATDF) in preparation for its sale to SVTC Technologies (Ladendorf, October 12, 2007), Yet the planned sale will ultimately expand capabilities and employment as the facility is used by nanotechnology startups as well as the semiconductor industry (Ladendorf, December 4, 2007 and December 9, 2007).

For Table 5, industry informants provided estimates of current semiconductor manufacturing employment, breaking down the numbers of contingent workers and employees, and operators and technicians. Most of the companies only used contingent workers for operator positions. Please note that some of the numbers below are estimates and approximations.

**Table 5. Data on Operators and Technicians based on Information from Industry Informants**

| | Freescale | Spansion | Samsung 200mm | Samsung 300 mm*** | Samsung Totals | Totals |
|---|---|---|---|---|---|---|
| **Date of information** | **October-07** | **July-07** | **July-07** | **January-08** | | |
| Total Employment in Austin area | 5,014 | 1,000 ** | | | 1,250 ** | 2,500 ** |
| Total Operators Plus Technicians | 1,350 | 856 | 592 | 307 | 899 | 3,105 |
| Number of technicians directly employed | 650 | 285 | | | | |
| Number of technicians contract or contingent | 0 | 0 ? | | | | |
| Total Technicians | 650 | 285 | 236 | 174 | 410 | 1,345 |
| Number of operators directly employed | 475 | 450 | | | | |
| **Number of contingent or contract operators** | **225** | **121** | | | | |
| Total Operators | 700 | 571 | 356 | 174 | 489 | 1,760 |

* with some flexibility

Researchers conducted interviews and email communications between July and October 2007 with industry informants, who provided data for the above table. At the time of those communications, the informants estimated that Freescale had approximately 700 operators, of which 225 (or 32%) were contingent workers brought on through Manpower. Freescale employed 650 technicians across its two plants in Austin—all of which were directly employed by Freescale. At Spansion, 121 were temporary "contingent" workers hired by its staffing agency, Volt Services, while Spansion employed approximately 50 operators directly. In addition, Spansion employed 400 Wafer Fab Technicians (essentially an advanced operator position) and more than 275 Manufacturing Technicians. Samsung reportedly has approximately 236 technicians and 356 operators in its existing 200 mm plant, with about 20% of the operators contingent workers. As of January 2008, the Samsung 300 mm plant employed 307 operators and 174 technicians.

### Increasing Use of Contingent Workers

Partly as a response to cope with employment instability, Austin manufacturers have made increasing use of contingent ("temporary" or "contract") workers for entry-level operator positions by contracting with staffing agencies; the staffing agencies themselves employ the workers, who are stationed at the manufacturing facility. In most of the semiconductor companies, the staffing agency maintains a manager onsite, even though the semiconductor company managers provide assignments and operational control for the work. Our scans of semiconductor job postings in June 2007 revealed that virtually all operators were hired through staffing agencies (see appendices A and B).

The use of contingent operators is attractive to manufacturing firms because it serves as a buffer against downturns, offers a screening device to select promising workers, provides a means of outsourcing burdensome human resource (HR) functions, and is less expensive than using workers hiring directly, due in part to the relative costs of the benefit packages. While use of contingent workers resolves some problems created by volatility, it brings others, such as built-in turnover. As a general matter of policy and practice, manufacturers do not keep a contingent worker for more than 364 days in order to avoid the prospect of legally becoming a "co-employer" of that individual.

Presently, staffing firms fulfill functions of recruitment and screening contingent workers. Staffing agencies have traditionally attracted workers using "temp-to-hire" arrangements or the prospect of "converting" to direct or permanent employment as a lure. They tell workers "Come work for us and you may be selected as a regular employee of the (well-known brand name) manufacturer." In fact, manufacturers do continue to seek and hire promising workers from among its contingent workforce. The number of temporary contingent workers who are hired as permanent operators with manufacturers varies with the product market conditions; in Austin, it has declined substantially. For example, during the past year, at one manufacturer, only about five percent of contingent operators were converted into direct employees.

Due to a high degree of tool specialization (driven by manufacturing culture, lean manufacturing initiatives, lack of adequate training systems, etc.), the position of "operator" is generally very limited in scope. In interviews, industry informants noted that the work performed by operators does not offer much variety nor does it stimulate a high level of interest, especially among many contingent workers. The positions are characterized by notably high turnover rates—averaging as much as 10 percent per month.

Turnover rates for contingent operators are as much as five times higher than for operators directly hired. However, this is an unfair comparison because direct hire workers have been working for the firm longer. Less than one third of contingent workers stay with a firm through their potential full term until they "time out." Reportedly, turnover is highest in the period just after being hired and near the end of the contingency period. The first peak is due to attendance and performance issues or to difficulties adjusting to the demands of the job (e.g., working in a "bunny" suit, working 12-hour shifts, etc.). The peak in turnover near the end of the contingency period is largely due to workers leaving for another job. Among directly hired employees, turnover rates are lower for technicians than for operators.

When a contingent worker's period of temporary employment comes to an end, the departing worker often joins the unemployment roll until he or she gets hired into a new job. The staffing agency recruits and screens a replacement for the position. The turnover, as part of the process derisively referred to as "*churn and burn,*" presents problems for manufacturers, staffing agencies, and workers.

Workers are stuck in entry-level temporary jobs with little prospect of advancement and a dim long-run future in which the number of available low skilled manufacturing jobs are disappearing. They face financial obstacles in stopping work to go to school and upgrade their skills. Working compressed shifts poses scheduling problems that prevent them from taking classes. The staffing agency bears the costs of higher unemployment insurance rates and of recruiting and screening a replacement worker. The manufacturer fails to take advantage of the skills and experience that temporary workers acquire over their period of employment and must bear the expense of training a replacement temporary worker on the job. Finally, Austin Community College Electronics and Advanced Technology finds itself with an inadequate supply of students interested in electronics and thus produces fewer skilled graduates than the industry needs.

## Transitioning Contingent Workers - Council for Contingent Workforce Development

In 1999, some frustrated semiconductor managers and staffing agency leaders - from competitor companies - began brainstorming how to address the problems that they saw adversely affecting their companies and the workers. During the downturn in semiconductor employment these discussions were shelved, and then revived with the recent upswing of semiconductor manufacturing. These individuals formed a Council on Contingent Workforce Development (CCWD) composed of representatives from staffing agencies, manufacturers, and Austin Community College. The stated purpose of the CCWD is to "provide a forum for participating organizations to address and advance issues related to Contingent Workforce Planning, Training, and Management in the Electronics and Advanced Technology industry in Central Texas."

The model includes a "workforce sharing" transfer component to maintain continuity of employment for workers, a skill development component, and the Council itself – for developing the kinds of relationships that could ultimately broker and maintain solutions.

The foundation of the Council's model is maintaining continuity of employment for workers through "workforce sharing." Initial discussions between managers from Freescale and Spansion posed the question, "What if …" the staffing companies intentionally developed their incumbent contingent workers rather than accepting the "churn and burn" of the current system, and figured out a way to transfer workers timing out at one company to work at a different company without having them go through a layoff by the staffing agency, which could adversely affect their income and benefits.

In spring 2007, Freescale and Spansion distributed a "Request for Solutions" to selected staffing agencies (Manpower, Volt and Adecco). Adecco and Manpower responded with similar ideas (with some variations). With the responses in hand, Freescale invited Spansion personnel and teams from the staffing agencies to an all-day meeting to develop a vision for a new system. The staffing agencies agreed to try the new model, which would entail transferring or "transitioning", for example, a Manpower employee who timed out at Freescale into a position at Spansion. The process would not entail Manpower laying off the worker to be hired by Volt; rather the worker would maintain employment and benefits with Manpower. The arrangement was to be reciprocal so that when a Volt worker timed out at Spansion, that worker could be transitioned to Freescale without being laid off by Volt. Through May 2007, about 24 workers had been successfully transitioned. The arrangements were roughly reciprocal so that both staffing agencies accepted equal numbers of transferred workers.

## Training / Development / Preparation for Semiconductors

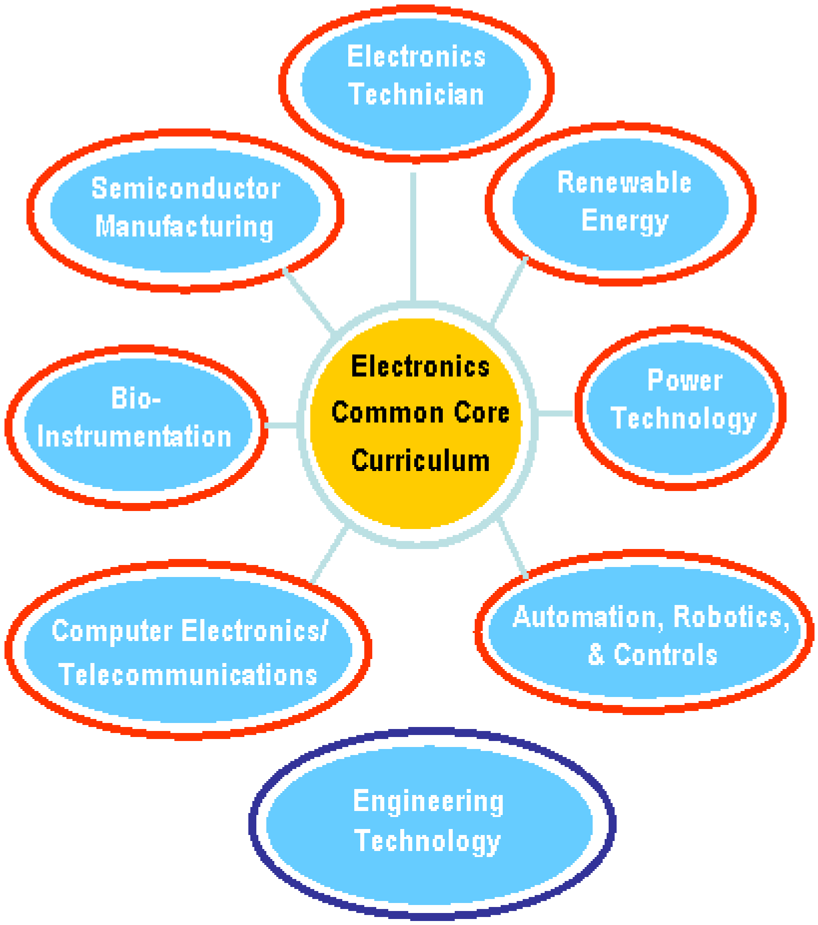
### *Austin Community College's Approach to Meeting Advanced Manufacturing Needs*

To serve the boom in semiconductor manufacturing during the 1990s, Austin Community College (ACC) established a separate department and program for training Semiconductor Manufacturing Technicians. After semiconductor employment suffered a steep decline in 2001, enrollment fell off and maintaining a specialized department was not viable. Thus, ACC sought a more flexible strategy for its electronics curriculum that could adjust more smoothly to changes in business activity, expanding or contracting when needed. Dialogue was held with an industry advisory group to develop consensus on a new strategy, establishing a set of core courses in electronics followed by specializations. The result, illustrated in Figure 3, helps both students and the college to adjust to the needs of the economy.

The Electronics and Advanced Technologies department of Austin Community College offers eight degree plans to help prepare students for specific careers, including technician roles in Semiconductor Manufacturing. Students can earn an Associate of Applied Science or a one-year Certificate in one of several specializations offered within the department. Electronics Technology degree plans center on a common core of 10 required electronics courses plus 5 general education courses, together with additional courses to complete the specialized degree. As of June 2007, seven specializations were available: (1) Automation, Robotics, and Controls Technology; (2) Computer Electronics/ Telecommunications; (3) Semiconductor Manufacturing Technology; (4) Electronics Technician; (5) Power Technology; (6) Bioinstrumentation Technology; and (7) Renewable Energy Technology. In addition, a separate degree option is offered for Engineering Technology, which includes much of the common core coursework but has more rigorous calculus-based mathematics and physics components for transfer eligibility to 4-year engineering degree programs.

An internship in industry is an integral part of each specialization. To earn an Associate of Applied Science in Electronics Technology, a student needs to complete the Electronics Common Core Curriculum, a set of courses satisfying the college's General Education requirements, and courses required for the student's choice of specialization. The department's modularized plan enables students to earn a second degree by taking only the additional (four to six) courses required by the second specialization.

**Figure 3. Curriculum Design for the Department of Electronics and Advanced Technologies at Austin Community College, July 2007**




TRAINING FOR BEGINNING OPERATORS

After a staffing company selects operators for work in a fab, the individuals are provided a few days of orientation and safety training followed by weeks or months of on-the-job training. Training on a particular tool or set of tools is conducted by a fellow worker who is certified on that machinery. In general, minimal training or skills development has been provided to contingent operators beyond how to operate required tool sets.

CCWD SKILLS DEVELOPMENT OPPORTUNITIES FOR CONTINGENT WORKERS

The Council for Contingent Workforce Development is seeking to promote learning and growth of workers by addressing obstacles for entry-level operators to access schooling to gain the knowledge and skills to qualify as technicians. Through CCWD, employers, staffing agencies, and ACC's Electronics and Advanced Technologies organized training opportunities for workers based on their work schedules.

Semiconductor production work shifts have presented a barrier to worker participation in traditional course schedules, since 12-hour shifts are scheduled several days in a row, e.g., Sunday-Tuesday or Wednesday, conflicting with a typical Monday/Wednesday or Tuesday/Thursday course schedule. CCWD partners organized cohorts of workers, so that the first cohort works Sunday, Monday, and Tuesday and every other Wednesday and their classes are scheduled on Thursdays and Fridays. The second cohort has its work and study schedule reversed. If a worker is transferred to a different shift, he or she can also be transferred to the other training cohort.

In addition, the CCWD partners set up an Education Bonus Program, funded by the semiconductor companies and staffing agencies, to offer advance payment for educational expenses (up to about $700 per semester, based on good work performance and grades earned) to take courses toward an associates degree or certificate in the ACC Electronics and Advanced Technologies program. The level of the Education Award for each semester is based on grades earned the previous semester, with all students in the program receiving 85% financial support in advance (the rate for a B average) for the first semester. Worker-students must take two ACC courses and maintain passing grades to stay in the program. At this rate of course taking, and Associate's degree can be attained in three and a half years.

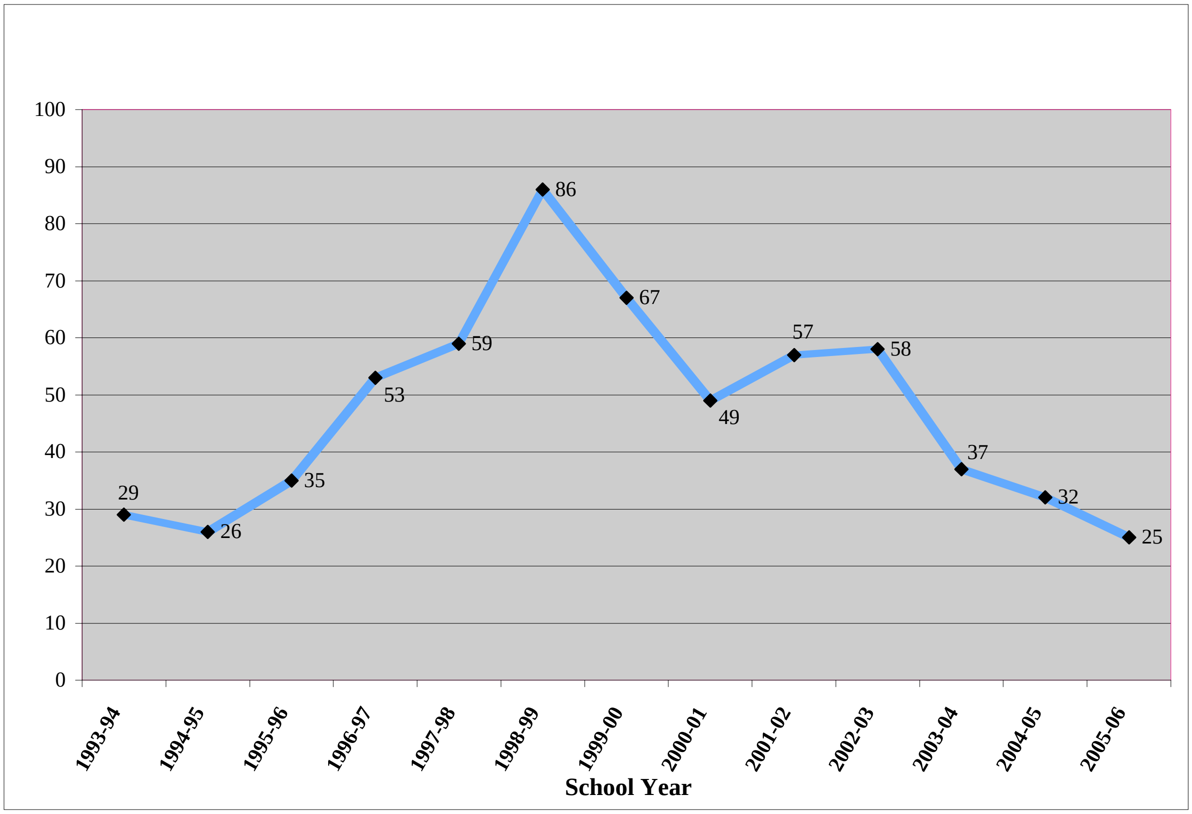
The educational assistance program was established to address the concern that operators working at $10-12/hour may find educational expenses for tuition, fees and books to be barriers to participation. Dr. Aguilar, chair of the department of Electronics and Advanced Technologies at Austin Community College points out that scholarships alone cannot always make it possible for workers to attend school; they need money to live and support their families. He explains that the Council's model that subsidizes education — enabling participants to participate in skills training while holding a job — is more responsive to the needs of these workers.

## Key Issues for Workforce Development

### *Underutilization of ACC's Electronics Program*

One situation that raises obvious concern about the future supply of skilled technicians for advanced manufacturing in Austin is the low number of individuals enrolling and completing the electronics program at Austin Community College. Figure 4 shows the annual numbers of Associate of Applied Science degrees in electronics awarded by Austin Community College from 1993-94 through 2005-2006. The most disturbing part of this picture is that degrees awarded have continued to decline in the face of the recent recovery in Austin's semiconductor industry.

**Figure 4. Annual Number of Associate of Applied Science Degrees Awarded in Electronics by Austin Community College: 1993-94 through 2005-2006**




The problem is not one of insufficient training capacity. According to Department Chair Dr. Aguilar, Electronics and Advanced Technologies at Austin Community College is operating at about 25 percent of capacity. Further, ACC's capacity for instruction in electronics will increase dramatically with the establishment its new campus in Round Rock. Assuming all goes well with the upcoming vote to annex the full Round Rock Independent School District into the ACC taxation district, the college plans to build its largest campus in Round Rock, serving as many as 10,000 students. As part of this effort, it may add electronics courses at Round Rock, thus further expanding the capacity of ACC in electronics.

Since the electronics program requires a minimum of 2 years for students to complete a degree, one would expect some lag in the rebound of graduates after the industry recovered from the sharp decline during 2000-2002.

The department has been taking action to increase its enrollments. Specifically, Dr. Aguilar cited four initiatives:

1. The specializations with the core curriculum in electronics are catching the attention of additional students;
2. The availability of increasing numbers of paid internships in industry is attractive to students;
3. The department has introduced greater flexibility in class scheduling to accommodate student needs. Classes are now offered in Monday-Tuesday and Thursday-Friday combinations. Courses are offered at several times – morning, afternoon, early evening, and late evening – to accommodate

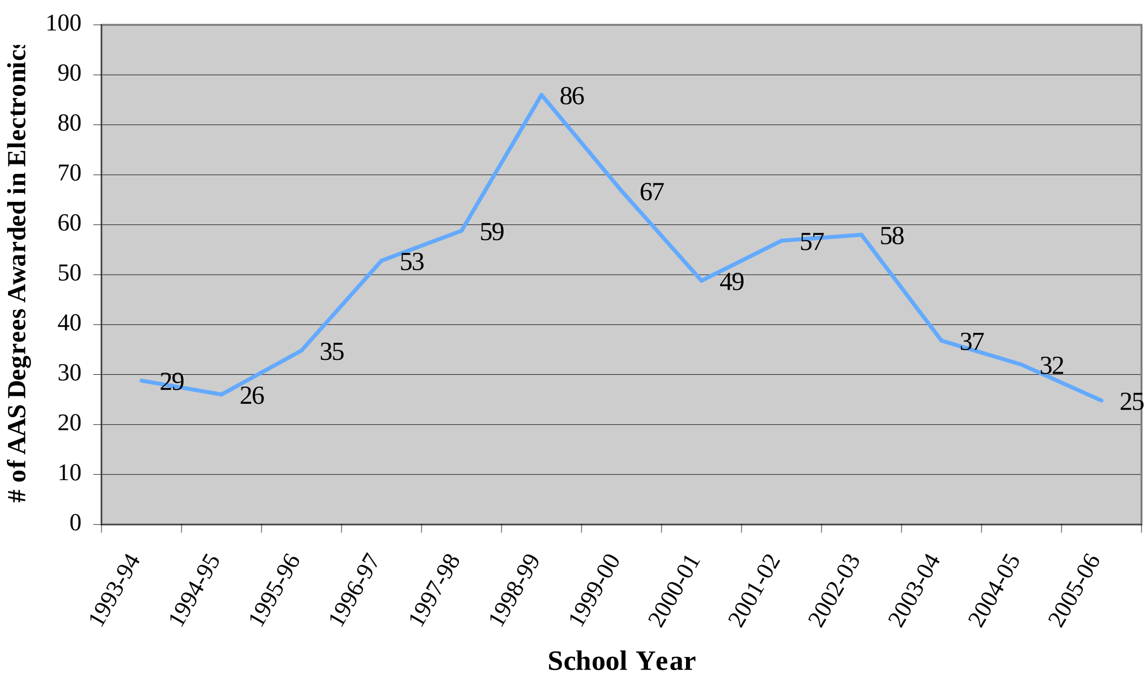
workers on various shifts. The department is even contemplating offering Saturday classes.

4. The college and the department have expanded marketing and outreach.

As shown in Figure 5, course enrollment levels in electronics in fall 2006 and 2007 are above where they were in fall 2004, but they have not started any significant upward trend.

Recruiting additional students in electronics is a task that the college can best accomplish with industry assistance–as demonstrated by Austin's experience in recruiting candidates for semiconductor technician training in the 1990s. Faced with the challenge of staffing several new fabs, industry leaders in Austin's semiconductor industry formed an organization entitled the Semiconductor Industry Executive Council, composed of leading executives from the industry and education. The Council joined Austin Community College in a campaign to raise enrollments. A semiconductor industry campaign called "Destination Digital" was begun, with print and web-based information and recruiting materials. Special evening open house meetings were arranged for students and their parents held at local industry facilities. Regular briefings about the program were held at the Austin Community College Riverside Campus with presentations from both Austin Community College officials and industry representatives. Follow up contacts were made with individuals who attended the sessions. In addition, several summer internships were offered to high school students to give them direct experience with manufacturing.

**Figure 5. Austin Community College: Total Fall Course Enrollments in Electronics, 1994-2007**



When Austin's semiconductor industry went into a downturn in 2000-2001, firms had less need for technicians; the supply of available technicians was plentiful. So the industry-wide intensive recruitment efforts subsided. The special meetings and briefings to recruit young people to enter community college were no longer held. The number of internships for high school students declined.

The Semiconductor Industry Executive Council has evolved into the Central Texas Technology and Education Executive Council (TEEC), which remains an important vehicle for direct communication between industry and educators. Its industry membership continues to be primarily drawn from firms involved with the semiconductor production. Members from educational institutions include administrators from local collages (including Austin Community College) and superintendents from local school districts. The Council is staffed by Skillpoint Alliance (formerly the Capital Area Training Foundation), a non-profit community intermediary organization dedicated to convening, connecting, measuring and sustaining regional workforce and education efforts.

The TEEC has maintained some activities focused on secondary school teachers and students, but the interests of the group have shifted more toward promoting engineering education in four-year colleges rather than technician training in two-year colleges.

In any case, the current low number of graduates in electronics is certainly a root cause of any future shortage of technicians in Austin and it needs to be addressed in finding solutions. Despite determined efforts, Austin Community College does not yet seem to be able to build enrollments at the expected scale necessary.

This challenge is not unique to Austin; it is symptomatic of a national issue. As Holtzer and Lerman (2007) recently pointed out:

> *Recently a great deal of attention has focused on the need for the U.S. to invest more heavily in its college-educated workforce, and particularly in the STEM [Science, Technology, Engineering, Mathematics] fields. Much less attention has gone to the need for more education and training for middle-skill jobs — those that require postsecondary education, but not a bachelors degree.*

Based on a review of national employment projections from the U.S. Bureau of Labor Statistics, Holtzer and Lerman conclude that "substantial demand remains for individuals to fill skilled jobs in the labor market, with many jobs there paying quite high wages" and that "at a minimum, that demand for mid-level skills will remain robust in the future" (p. 29).

In November 2007, more than 100 national, state and local organizations joined together in The Workforce Alliance to launch *Skills2Compete*, a non-partisan campaign to "ensure that the U.S. workforce has the skills to meet business demand, foster innovation, and grow broadly shared prosperity." The list includes industry associations, such as the National Association of Manufacturers, individual firms, educational institutions, community organizations, and advocacy groups. Their special focus is skilled jobs in the middle of the labor market, requiring less than a bachelor's degree (www.Skills2Compete.org).

### CCWD pilot experience with "transition" and training

The Council's pilot program was designed to be a "win-win" arrangement for all parties:

- <u>Workers</u> would maintain more continuous employment, earnings and benefits, along with opportunities for growth and learning. Operators would gain opportunities to upgrade their skills to become technicians (who enjoy higher earnings and more regular employment than operators because technicians are less likely to be laid off during downturns). The CCWD project was designed to overcome two key obstacles to taking courses: lack of available financing and problems with scheduling. In brief the solutions devised are to have the manufacturer (and/or staffing firm) coordinate school and work schedules and provide tuition assistance in advance for workers who perform well at work and in school.

- Manufacturers would gain access to a larger pool of workers who are more competent and qualified through training at ACC and their accumulated on-the-job experiences.
- Austin Community College would gain a new source and an enhanced flow of applicants into its electronics program and semiconductor courses. The arrangement also provides students with a variety of practical on-the-job experience.
- Staffing agencies would gain financially because their contract workers remain more continuously employed, thus reducing recruitment, assessment, and management costs including risk of greater unemployment insurance costs, as well as increasing return on investment for these activities through achieving more billable hours per worker.
- The state of Texas would benefit from fewer claims on unemployment insurance funds and a more competent workforce to attract and maintain industry.

The CCWD initiative remains in a pilot stage of implementation.

### *Transitioning contingent workers between semiconductor companies*

Implementing the “transfer/transition” part of the model has been the most difficult, despite the group’s experience transitioning about 24 workers who timed out at one firm to a job at the other firm, remaining on the payroll of the original staffing agency, with the numbers that have transferred each way roughly balanced out. From the perspective of the semiconductor companies and the CCWD staff, the staffing agencies have been “resistant” and have repeatedly “dropped the ball” on following through on the transfers. CCWD staff even did the legwork to chart out the contingent worker “tenure limits” and reminded the agencies, but the staffing agencies reportedly “forgot” to contact workers to find out if they were available and interested in transferring, instead going out to recruit new replacements. CCWD staff and semiconductor managers speculate that the agencies fear losing the immediate revenue, even though the numbers have been evening out in practice, since the transfers entail filling a slot from a competitor staffing agency rather than recruiting a new worker.

In addition, not all workers want to transition, depending on the location or circumstances of a subsequent offering. At this point, the eventual outcome of this initiative is not clear but the efforts hold promise as a means to upgrade the income and status of entry-level workers, including many workers who meet eligibility criteria for training services through the Workforce Investment Act.

### *ACC training opportunity for contingent workers*

The pilot educational program began in fall 2006 with nine students. Nine students were participating in the program in fall 2007. Leading up the fall semester 2007, Manpower and Freescale conducted a recruiting campaign to sign up operators for the program by meeting with small groups throughout the fab. In November 2007, Manpower and Austin

Community College held meetings with all contingent workers at Freescale to explain the program and distribute handouts. Talent recruiters for Manpower, Inc. have begun to promote this training opportunity as a benefit of signing with the agency. Manpower, Inc. has established a specialized website to recruit applicants to the program (www.us.manpower.com/i2c). These efforts are beginning to raise awareness about the opportunities available. An issue is to generate sufficient commitment and participation so that ACC can continue to make these specially scheduled classes available. If insufficient numbers of workers are recruited into the education program or if members of the cohort drop out, the courses arranged to suit their schedule may fall below the ACC minimum class size and need to be cancelled.

### ***Perspectives of Contingent Workers on Skill Development Opportunities***

In November 2007, project staff conducted focus groups (small group interviews) with semiconductor operators employed on a contingent basis at one semiconductor company to obtain their perspectives on their jobs, training opportunities, as their interest in training and careers in the semiconductor industry.

Eight focus groups were conducted, which attracted a total of 28 operators working on day shifts and night shifts at two different factories (fabs). The focus group participants comprised about 13 percent of the total contingent operator workforce at the fabs involved. The focus groups were conducted before or after work shifts on personal time. Each focus group lasted 50 minutes. All participants were volunteers, and were provided the incentives of pizza and beverages during the focus group and a $15 gift card to HEB Grocery Store.

Workers were invited to share their opinions whether or not they intended to further their education in electronics. The focus groups were especially centered on workers' interest in becoming semiconductor technicians and their perspectives regarding the CCWD pilot program offering tuition assistance and a course schedule that accommodated their work schedule.

Several of those interviewed already had bachelors or associates degrees or had previous technical work experience, even in semiconductor field, before the downturn several years ago, or with other electronics manufacturers, such as Dell or IBM. In addition, a few interviewees were enrolled in courses for other pursuits as diverse as nursing and physics, and some had professional experience in other fields.

#### WORK IN THE SEMICONDUCTOR INDUSTRY AND CONTINGENT WORK

*Instability and insecurity*

No one in the focus groups suggested technician jobs are undesirable. Indeed, the jobs and skills of technicians are well respected. Operators like the variety of work they see involved in technician jobs. They are attracted by the permanent status enjoyed by technicians and by the higher pay levels received by technicians along with their benefits as direct hire workers, especially health insurance and sick leave.

While several of the workers described liking work in the semiconductor industry, the technical aspects of the job, and the compressed shifts that allowed them whole days to tend to other pursuits, they overwhelmingly expressed concern about their temporary status and what they perceived as insecurity that came from being a contingent worker.

Several spoke about not having good health benefits, sick leave, or options for time off. They were concerned about getting sick or having a situation to take care of that would get them dismissed from employment. Some participants described being among a very few workers that made it to the plant during the ice storm last December, when company employees called in sick or to say that they would not come in. Workers who are near the end of their contract or working beyond their contract feel especially vulnerable as they are employed on a week-to-week basis.

- With the temporary status, you don't know whether you will be here tomorrow.
- Most of us are currently looking for another job because we have no idea whether we will be here.
- Why train for the semiconductor industry if I am not going to be working here in a month?

The sense of vulnerability related to other aspects of the work situation as well. Many workers expressed pride in their work but "Mis-processes put fear in the back of your mind," and "At the first sign of a mistake, boom and you are gone." They felt expendable and that they would not be given a chance to improve or to make something up. The level of fear or concern varied from group to group, but the desire for more stability and security was mentioned in most of the groups, by all but those who were just using the temporary work to make money while they pursued other options.

While many contingent operators have limited technical skills coming into the work, several focus group participants reported having associates degrees or prior experience as a technician, but that there were fewer opportunities to be "converted" to a permanent employee. They noted a "status difference" between the operators who were employed by the company and those who were contingent, saying that, "Having a [the staffing agency name] on your resume is of little or no help in getting another job," and also that "direct hire workers treat us differently," speculating that direct hire workers may feel threatened that the lower paid contingent workers will take their jobs.

A few years ago, employers regularly converted contingent workers into direct hire. For example, this company's regular practice had been to convert contingent workers into directly hired employees after 90 days, given good performance. Focus group participants said, "Today the only jobs available are temporary." One said that being hired by the company was much less certain even with good work performance and that, "(t)hey sell you a dream that you are not going to accomplish." Several workers expressed similar views, including concern about aging and attempting to raise families without any job security or benefits packages, saying, "I don't want to find that I am still a temporary worker when I retire." It is important to note that the concern expressed about their positions ending was not just in the event of a major economic or company downturn; they were worried that any mistake, or any need by the company to make up costs (even as a result of a loss stemming from process problems producing scrap caused by regular employees or a different shift) could result in immediate termination. As one said, "Whenever they need to make up some money, who are they going to cut? Us!"

For training and development, too, contingent workers felt that there was little attention given to developing their skills. Several reported asking supervisors what they could do to improve their performance, take more responsibility, and possibly be eligible for conversion to hire with the company, but that there was a pervasive sense that contingent workers were not valued or considered in the same light as employees doing substantively similar work. Several stated that they do not receive helpful supervision or feedback. "I get a lot of 'atta-boy's' but I hear no constructive evaluation or recommendations about how I can improve." One recalled his supervisor saying, "You have already got one strike against you because you are from (the staffing agency)."

Several mentioned that internal job postings in the fab say, “not available to temporary workers.”

Workers pointed out that the training time for new workers recently had been compressed into two days. One worker complained, “They rush you though as fast as they can and you end up not prepared for work on the floor.” Some interpreted this abbreviated initial preparation as a lack of commitment to training and felt that the slimmed down training also “cheapens the job—especially when temps come in unqualified.” Another explained, “They give you just enough information to get by—but not enough to get ahead.”

New operators on a tool set receive training on the job from an employee who is certified on that tool set. Focus group participants said that the learning depends a lot on the initiative of the contingent workers themselves to ask questions. The quality of the training also varies considerably with the competence of the trainer. Some of the new operators reported that their trainer would just tell them to push a series of buttons, or to follow a series of steps with the designated tool or machine that they would be working on, and were unable to communicate about the task in a larger context of the process or product. Some of the participants recommended that those employees selected to train new workers be expected to have communication and “teaching” skills, beyond proficiency with the tool itself, and to be able to convey information about the tool and its relation to the overall process. Workers did say that they were generally able to find someone to help with questions after working for some time, but “if you got a bad trainer [who couldn’t explain things], you could stay confused for quite a while with no one to ask for help.”

Rotation on various tool sets is commonly practiced within departments; but rotation across departments is rare. Procedures are in place to qualify and certify employees on various toolsets. Certification records are maintained in the manufacturers’ database (in part, to fulfill requirements of the ISO 9000 qualification process).

### Views on the CCWD-ACC Program

Workers in the focus groups agreed that the educational opportunities through ACC (the schedule coordination and tuition assistance in advance) were generally well designed and attractive. They view the program as both desirable and feasible. (This point was especially emphasized by workers who are struggling to go to school on their own in another field while working full time). Workers interested in the program viewed it favorably. The program seemed most attractive to young workers interested in electronics/mechanics (stated several ways, such as “I like technology” or “I like electronics” or “I like to fix things” or “I like tinkering”) without other degrees. Many of the participants said that they were impressed by the flexibility of the program in that they could take courses in a number of advanced technology specialties.

Several workers noted that they had heard of the program previously, but had not really understood the options until the recent announcements and meetings with the staffing agency. There had been several misconceptions about who was eligible to participate, and how the educational award worked (several had previously thought that the award was only to help with books — not tuition and fees). Focus group participants acknowledged that they now had a better understanding of the opportunity, and many said they were more interested. However, questions remained about what would happen to the worker’s eligibility to participate in the class and to have that class paid for if the worker was laid off during the semester, or if a job change at mid-semester that prevented the worker from maintaining the class schedule. In particular, they were concerned about their financial obligation for the classes and having a course commitment built around a job that no longer existed.

The operators certainly did not all aspire to be technicians. Some were simply not interested in a career in the semiconductor industry. Some viewed their contingent operator jobs as a temporary expedient while they pursue education in another field or seek a permanent job elsewhere. For some workers, availability of a compressed schedule night shift is an attractive aspect of the job, providing them a block of time during the day when they were off to take care of other responsibilities or pursue other interests. Some reported working several jobs on different shifts. A few became interested in a career in semiconductors after becoming familiar with the industry through their temporary job.

The elements of insecurity and lack of guaranteed reward translated into hesitation on the part of several participants. "What is the point of going to long-term training if there is no commitment of a job at the end of it?" They said that the staffing agency "could point to only one person (from the program) who has been promoted," but that they were aware of a number of contingent operators with some combination of associates degrees, training in electronics, technical experience, and good work records, and they still had not been able to "convert" to a permanent position. This was disheartening for those workers themselves, and for their colleagues. As one stated, "If he can't make it, what makes me think I am going to?" The fact that these individuals have not advanced to technician jobs discourages others from starting in training.

While there was enthusiasm among many of the participants for the offer of education assistance, some worried about maintaining good enough grades to receive full financial assistance. Notably, no one raised concerns about passing the Texas Success Initiative (TSI) tests to qualify for taking college courses, nor was any apprehension expressed about passing the mathematics portion of the test, though one person did complain about having to pay the testing fee.

Workers did express concerns about the class schedule, such as needing a break after working four days in a row, having time to complete homework if classes are held on consecutive days, and being able to schedule the general ACC foundation courses required for the degree but not scheduled around work shifts. Others had financial or personal responsibilities or barriers that they felt precluded them from participation, such as a single parent who provided child care during off days, and a worker encumbered by substantial debt from previous technical education.

Some expressed interest in entering the program but said that they "needed to get some things out of the way" before they started. Several anticipated that by fall 2008, they would be ready to enroll.

Overall, the educational component of the CCWD model looks promising for skill development if some basic issues can be addressed.

## Recommendations Going Forward

These recommendations fall into the four categories: (1) recommendations regarding the workforce development for contingent workers, (2) data collection to improve planning and decision-making, (3) recruitment and outreach, and (4) institutional development to expand and sustain the initiative.

### Recommendations on Workforce Development for Contingent Workers

For the educational component of the CCWD model to be utilized more, barriers and concerns identified by the workers should be addressed. It is important to note that project researchers were only able to speak with contingent workers from one company for this report. Other companies may have other circumstances or conditions that would change some of these conclusions and recommendations. Still, if training conditions in the companies are similar, for example, the comments and recommendations may be directly applicable. Other companies seeking to have a more motivated contingent workforce and to promote further skill development among contingent workers may still wish to consider these recommendations to determine applicability.

*1. Communicate clearly — and regularly — about both the employment and the education components of the program, and address worker questions and concerns.*

Promote the program using brief written handouts explaining the program features, the schedule, the education advance, and the various degree opportunities in the Electronics and Advanced Technologies program, as well as answers to those frequently asked questions about how changes to their work assignment would affect their course participation and their finances. Continue to share information about the program through verbal briefings where questions can be raised, in addition to providing written details.

The workers are not generally aware of transferability of electronics training to other industries. This point could be emphasized more in recruiting for the program.

*2. Show workers that there is a payoff for skill development.*

Job insecurity is a key factor inhibiting contingent operators from committing to long-term education. They feel highly vulnerable to losing their job. “Why should I enroll in education when I am not sure I will be here next week?” asked one. They see no examples of operators who got promoted due to their participation in Manpower-ACC electronics education. Indeed, a few of their fellow workers already have training in electronics and/or long experience or knowledge in the industry, but that does not get them promoted. These counter-examples undermine the efforts to recruit workers into education classes.

Recruiting will become much easier once success cases are available to showcase. Successful participants will ultimately become the best recruiters for the program. Success of the education program will require long-term commitment on the part of staffing agencies and the industry. Unfortunately, it will take three to four years to produce the first graduates of the program. One suggestion to shorten this timeframe is to consider providing advanced standing in the program where appropriate to workers who have partial training and/or significant experience in electronics, enabling them to complete and become promoted on an accelerated basis.

*3. Improve on-the-job training and performance reviews.*

The minimal training given to new operator recruits and their mixed experience with on-the-job training at the fabs conveys the idea that training is not valued much in this cost conscious lean manufacturing environment. The operators do not receive performance reviews that give them constructive feedback about how to improve their work and develop their skills. Advancement paths are not well indicated or obvious. They felt stymied by job postings that explicitly tell them that contingent workers are not eligible.

Some workers who are serve as trainers are skilled at using a certain tool set, but are not effective communicators or trainers, at least in the eyes of those who need to learn from them, and whose job performance depends on their training. In particular, some trainers provide a very limited set of instructions with little context about the overall process. Providing assessment and development to the workers selected to train new operators, may improve the productivity of new workers early in the process, and reinforce the message that knowledge and skills are valued.

The on-the-job training component of the program could be improved to extend experiential learning opportunities for participants in the program and help motivate them. Program participants could be placed on a different track that would explicitly offer training on the job, providing exposure and training to a wider variety of tasks — including to some of the simpler technician tasks, such as cleaning toolsets, preventive maintenance and tool qualification. A skills profile checklist could help formalize the planning process for operators to develop skills as they are working. While rotation on the job would make assignments more effective for experiential learning, it may be difficult to implement, and impossible without the strong commitment on the part of the company to invest in this manner in temporary workers.

*4. Monitor and follow up to motivate the progress of the worker/students.*

Keeping contingent workers motivated through the full duration of the program will require monitoring, personal attention and follow-up. Currently, in-plant supervisors are responsible for the trainees. Although this makes some sense because supervisors sign off on the tuition advances provided to worker students, supervisors may supervise several dozen workers and they are extremely busy with other responsibilities. Further, the supervisor of a trainee will change from fab to fab. It may be more effective to make a single person responsible for continuous monitoring and for acting as an ombudsman when needed.

*5. Consider ways to implement progressive wage increases as skills improve.*

It is probably unrealistic to keep trainees motivated through at least three and a half years of full time work and classes while continuing to earn only $10-$12 per hour. Successful trainees must be both ambitious and persistent. They are likely to be offered better paying jobs, especially if the labor market tightens as their skills develop. Conceivably, wages could be progressively increased as skills increase. But if wages are increased beyond entry levels, subsequent employers will need to honor them as well.

*6. Continue and expand ACC's involvement in presenting the program to potential participants.*

Most contingent workers have a positive view of the electronics program at Austin Community College, but few have taken the initiative to check it out or to actually make application. Manpower now conducts part of their job preview at Austin Community College Electronics Department. Making application to Austin Community College is an integral part of the application process to Manpower. Given what we found in interviews with workers, connecting with ACC is an excellent initiative. It gives workers a direct experience with ACC, and familiarity with the college's location, program, and application process. It also helps to reinforce the importance placed on education.

*7. Continue to refine the program design to improve access.*

While electronics courses have been scheduled during off days, the schedules for required the five general education courses required have not been similarly tailored to accommodate the work schedule.[1] This presents schedule problems for some workers.

One individual recommended that at least some required courses be made available on the Internet so that students could take them on their own time.

### RECOMMENDATIONS REGARDING DATA

*8. Address data gaps that impede clear workforce planning.*

Because government data does not distinguish technicians from operators, nor contingent workers from workers directly hired, the only source of this data is the industry itself.

Ask major employers to partner with *Work*Source by providing data on contingent and employed operators and technicians on an ongoing basis at all the major firms. Obtain agreement from the firms on their willingness to provide this information annually or bi-annually. Devise a simple electronic survey, which could be completed in 5-10 minutes by the right person in the Human Resources Department.

### RECOMMENDATIONS REGARDING INSTITUTIONAL DEVELOPMENT TO EXPAND AND SUSTAIN THE INITIATIVE

*9. Expand the workforce development model beyond the semiconductor cluster into a broader selection of advanced manufacturing firms that use contingent workers.*

The concerns that contingent workers expressed about lack of opportunity to access promotions within their current temporary assignment reflect a limited view of the greater opportunities that could ultimately be offered through the contingent workforce development model. In the knowledge economy of the twenty-first century, maintaining employment and employability increasingly depends on continuous skill development. The high-tech workforce operates within an economy in which occupational communities and networks of skilled workers are as important as firms (*See* Barley and Kunda, 2004).

To meet the demands of the high-tech manufacturing economy, the contingent workforce development model should offer a matrix of related contingent assignments across the advanced manufacturing cluster. When structured to offer training combined with education, the result will be a series of internships providing participants providing a broader range of knowledge and experience. One intended effect will be to move the worker's focus from any specific assignment to the development of knowledge transferable among related technician opportunities within the advanced manufacturing cluster. This in turn should lead improved worker motivation.

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[1] This issue may be difficult to resolve for the three of the five general education courses that are electives, unless all student workers in the cohort enroll in the same courses.

10. *Create an organizational structure within the staffing industry capable of managing the contingent workforce model, with input and support from client manufacturers.*

The problems of transitioning workers between assignments experienced to date by the CCWD are evidence of a larger challenge for the contingent workforce development model. The staffing industry must assume the lead role in this change in practices and serve as the primary link among manufacturing cluster participants, the workers, and educational institutions.

To successfully attract and assess workers, guide transitions, track worker performance, and manage a strategic assignment matrix, a new organizational structure needs to be created within the staffing industry with defined roles and responsibilities significantly different from traditional roles. Staffing companies that develop such a structure may reap benefits. They can stabilize their contingent workforce, lower costs of unemployment insurance and turnover, and enhance their revenue prospects. They can also attract more motivated workers and new client companies that can complement the staffing firm's strategic position within the cluster.

## RECOMMENDATIONS REGARDING RECRUITING AND OUTREACH

*11. Revitalize recruiting partnerships between industry and ACC. If employers are feeling the pinch because there are not sufficient numbers of technicians, the time to begin active recruiting for feeder training programs is now.*

This strategy has been effective in Austin in the past, and requires semiconductor employers to anticipate future workforce needs and invest resources to meet them.

*12. Ask incoming students in the Electronics and Advanced Technology program about the source of their interest, what attracted them to the field, how they became aware of job opportunities and available training, and their suggestions for outreach to other potential participants.*

It is not clear what messages are appealing to the "emerging workforce" and how to target students who would be most likely to pursue technician-level training. Consciously seeking answers from new enrollees could help to target future outreach and marketing efforts.

*13. When conducting outreach to high schools, distribute brief (anonymous) surveys of students to learn their impressions about career opportunities in the field and the training available.*

As with the previous recommendation, ACC could use this information to improve outreach and program design, and to provide information to employers that would help to attract a larger pool of qualified candidates.

# NANOTECHNOLOGY

> "Nanotechnology is not a science, it is multi-scientific. Nanotechnology is not an industry, it is multiple industries."
>
> Applied Nanotech, Inc., Austin, Texas

## Background

Nanotechnology is the understanding and control of matter at dimensions of roughly 1 to 100 nanometers, where unique phenomena enable novel applications. In the metric system, the word "nano" refers to "billionth"; thus a nanometer (nm) is a billionth of a meter. Put another way, this is about 1/50,000th the width of a human hair. The availability of new tools able to observe and manipulate atoms and molecules have made nanotechnology possible.

After more than twenty years of research, nanotechnology processes have begun to come into commercial use. Today, consumers can purchase several products manufactured using nanotech processes. For example, the cosmetics industry uses nano-particles in lotions, creams and shampoos. Nano-sized zinc oxide particles are used in sunscreens. These particles are particularly good at absorbing ultra-violet rays, but make the lotion transparent and smooth instead of sticky and white. The clothing industry uses nanoparticles of silver to make stain-repellent fabrics. A chemical process used during manufacture forces liquids to bead up when spilled on a garment for easy wiping away. Also, socks that are made with nano-silver particles give anti-microbial protection, preventing bacteria and fungus that cause itchiness and smells. Nanotechnology is used to produce glass windows that are self-cleaning. The windows are coated in highly activated titanium dioxide, engineered to be highly hydrophobic (water repellent). Nanotech coatings are used on tennis rackets and golf clubs to make them stronger. Even food ingredients produced through nanotechnology are available. One company has developed a nanotech approach for introducing antioxidants into food and beverage products easily and effectively. The electronics industry has been a leader in commercializing nanotechnology, using it in products such as semiconductors, computer hard drives, non-volatile magnetic memory, and solid-state compasses.

The Project on Emerging Nanotechnologies, established in April 2005 as a partnership between the Woodrow Wilson International Center for Scholars and the Pew Charitable Trusts, maintains a continuously updated inventory of available nanotechnology consumer products and manufacturers (http://www.nanotechproject.org/inventories/consumer/) As of October 2, 2007, the inventory contained 580 products or product lines from 20 countries. The United States led internationally with 55 percent or 317 consumer products produced through nanotechnology in eight categories:

- Appliances (Heating, cooling and air; large kitchen appliances; laundry and clothing care)
- Automotive (Exterior; maintenance and accessories)
- Goods for Children (Basics; toys and games)
- Electronics and Computers (Audio; cameras and film; computer hardware; display; mobile devices and communications; television; video)
- Food and Beverage (Cooking; food; storage; supplements)
- Health and Fitness (Clothing; cosmetics; filtration; personal care; sporting goods; sunscreens)

- Home and Garden (Cleaning; construction materials; home furnishings; luxury; paint)
- Cross-Cutting (Coatings)

In October 2007, the largest category of products using nanotechnology was health and fitness, especially cosmetics, clothing and personal care items.

The Project on Emerging Nanotechnologies aims to help "ensure that as nanotechnologies advance, possible risks are minimized, public and consumer engagement remains strong, and the potential benefits of these new technologies are realized" (http://www.nanotechproject.org/7/mission). Also available through the Project is a nifty interactive map of the United States locating companies and research facilities producing nanotechnology products. Austin and Houston are listed among the top 12 metro areas for nanotechnology (http://www.penmedia.org/maps/mappage.html).

Nanotechnology is not an industry on its own. Rather nanotechnology applications will be used in a variety of industries. Nanotechnology is a convergent technology with applications in several industries targeted by Austin's economic development efforts, including semiconductors and electronics, clean energy, biotechnology and diagnosis, medical devices, and others.

### Economic/Employment Factors and Job/Skills Outlook

There is a considerable amount of "buzz" or "hype" about nanotechnology. Some experts have predicted that over the long term, nanotechnology could be as significant as the steam engine, the transistor, or the Internet.

In 2000, an often-quoted workshop sponsored by the National Science Foundation projected that by 2015, the global market for nanotechnology-related products will reach $1 trillion and employ 200 million workers (National Science Foundation, 2001, p. 3). More recently, Lux Research projected that nanotechnology will impact $2.9 trillion worth of products by 2014 (Lux Research, 2007). Similarly, another consulting firm, Cientifica, estimates the "Global Nanotechnology Market" by 2015 as $1.5 trillion excluding semiconductors and $2.95 trillion including semiconductors (2007). Governments all over the world are pouring monies into research and development efforts on nanotechnology.

The predictions are generally overstated. Market forecasts of nanotechnology typically do not measure the value of only actual nanotechnology products. Rather they combine the total value of technology-*enabled* products. Thus, the entire value chain of these products is counted rather than solely the value that nanotechnology contributes.

Currently rather than producing entirely new products, nanotechnology is primarily used to improve existing processes, materials and applications by scaling down to the nano range to take advantage of unique chemical and physical properties that materials exhibit at these very small dimensions. The quest is improve existing products by producing smaller and better performing materials at lower cost. When a 15¢ ingredient is improved and used in a $4.00 bottle of sunscreen, should the entire value of the sunscreen be counted as part of "the market for nanotechnology?" Or when composites with carbon nanotubes are added to materials used to make stronger and lighter bumpers on Toyota trucks, should the entire value of the bumper or even the truck be included as part of the market for nanotechnology? These examples illustrate the confusion in valuing the nanotechnology market.

A similar exaggerated process is used in data on the labor market impact of nanotechnology. If nanotechnology affects even a few workers in an occupation, the U.S. Bureau of Labor Statistics counts the full projected number of persons in that occupation as being impacted by nanotechnology. Indeed national websites such as *O*Net On Line* and *Career Voyages* (sponsored by the U.S. Department of Labor and U.S. Department of Education) identify 48 occupations as "nanotechnology-related" with a projected need for 2.5 million workers through the year 2014. Included in the count of the "in-demand nanotechnology labor force" are occupations such as team assemblers, helpers-production workers, computer support specialists, electronics technicians, first line supervisors, welders, and 42 others (see http://www.careervoyages.gov/nanotechnology-main.cfm and http://online.onetcenter.org/find/indemand?i=NAN&g=Go)

### *The skills required to work in nanotechnology*

As one interviewee explained: "Nanotechnology is just an extension of science." Thus it makes most sense to build knowledge of nanotechnology on a base of science or engineering or technical preparation. Applicants who aspire to work in nanotechnology need a strong background in science and mathematics. As a new and exciting field, nanotechnology has a special appeal to youths. In part this due to its potential to resolve pressing world problems such as developing clean energy, curing cancer and other serious diseases, etc. As such, nanotechnology can be an effective lever to encourage greater interest in science and technology. At this point in time, there is no such occupation as "nanotechnician." Thus, there is not yet any general skills profile for a nanotechnician. However, there are electronics technicians who work with and maintain nanotechnology tools. Molecular biologists use nanotechnology in their laboratory work. Engineers use nanotechnology to develop new products. Knowledge of nanotechnology is best viewed as a supplement to a strong technical, scientific or engineering background.

A nanotechnology employer told us, "Anyone with expertise in electronics, intellectual curiosity, and a keen interest in nanotechnology may be an ideal candidate for a job in my firm."

As long as nanotechnology remains primarily a research activity conducted in university labs and R & D facilities of private businesses, workforce needs will emphasize workers with advanced degrees, such as scientists, physicians, researchers and engineers. Still some associate degree holders employed in nanotechnology now. For several years, two ACC graduates in electronics have helped maintain equipment at the Microelectronics Research Center, one of the two major nanotechnology labs at the University of Texas. Also, fully one quarter of the jobs posted in May 2007 by Austin-area nanotechnology companies required no more than an associates' degree but with extensive job experience in a specialized area (e.g. photolithography). However, as nanotechnology moves into the manufacturing stage, there may be greater demand for a workforce with specialized community college training at the technician level.

Nanotechnology will have a big impact on manufacturing. Obscure at this point are answers to the questions: How will it develop in Austin? What demands will it place on work force knowledge and skills?

The answers to these questions will vary from industry to industry. For example, in the alternative energy field, Heliovolt, an Austin firm working at the nanoscale level, has developed an economical process to manufacture CIS (Copper Indium Selenide) thin film material for generating electricity from sunlight. The CIS thin films then can be applied to a variety of construction materials including glass, steel, metal, composites and some plastics. The firm has decided to locate its manufacturing facility in Austin is expected to create new 168 jobs. Reportedly, this new technology is not expected to require production workers to have any special knowledge of nanotechnology. Rather it calls for technicians who are familiar with semiconductor production because the deposition process used in Heliovolt' production is similar to processes used in the fabrication of semiconductors. Thus the company is seeking equipment maintenance personnel with experience in the semiconductor industry.[2] Nevertheless, the next generation of solar equipment is anticipated to be based on organic processes enabled through nanotechnology; it will require workers who have some knowledge of nanotechnology.

## Training / Development / Preparation for Nanotechnology

### *Nanotechnology Programs in Community Colleges*

Over the past three years, universities and community colleges across the country have begun to establish a variety of academic degree programs related to nanotechnology.[3] The chart in Figure 4 provides a sampling of community college programs related to nanotechnology that now exist across the US. Several were begun with funding from the National Science Foundation, especially its Advanced Technology Center (NSF-ATE) program. Most have few students (e.g., 5-15) enrolled at this point. Some programs began by offering a single introductory course in nanotechnology, then growing the program from there.

There is considerable variety in the focus, structure, degree and credentialing arrangements. One approach is to offer a specialization in nanotechnology, which is added to an existing program of study in science, technology or engineering. This specialization can be in the form of a certificate (or a minor in a bachelor's program, such as is available at the University of Pennsylvania or at Georgia Tech University.) The specialization may be cross-disciplinary or narrowly focused in one area of nanotechnology, such as nano-biotechnology. In an alternative approach, community colleges across Pennsylvania offer specialized degree programs, such as AAS degrees in Nanofabrication Technology. Dakota College in Rosemount, Minnesota offers an AAS degree in Nanoscience Technology.

Collaboration between universities and community colleges. Most community college nanotechnology programs are commonly operated in partnership with a nearby 4-year university. In some programs, this arrangement allows community college students have access to laboratory equipment and clean-room research facilities on the university campus. Generally, the 2-year program is linked to the 4-year program through an articulation agreement, which allows community college courses to transfer to the 4-year institution and qualify for credit toward the bachelor's degree. Pennsylvania State University has a statewide articulation agreement with community colleges. Pennsylvania also has a statewide tech prep articulation agreement between community colleges and high schools across the state.

Pennsylvania State University offers a one-semester capstone course to students from 2-year colleges across Pennsylvania. In California, the NanoSystems Institute at the University of California-Santa Barbara since 2001 has provided 8-week summer

[2] This information was confirmed in an E-mail from David Hughen, Vice President for Human Resources, HelioVolt, to Robert W. Glover, December 4, 2007.

[3] The website, *Nanotechnology Now* (http://www.nanotech-now.com/academic.htm), lists 846 academic programs, research labs and collaborations of various types. It also provides links to their websites.

internships in NanoSystems Science, Engineering and Technology (INSET) to California community college students.

As previously indicated, partnering with a four-year university generally provides a community college with access to expensive nanotechnology lab facilities and equipment. However, the nature of the access varies significantly—from simple tours to the actual training in the lab. As an example of the former, students in Nano 101 at North Seattle Community College meet on two Saturdays per semester at the Washington Technology Center at the University of Washington. More intensive involvement can be found at Hudson Valley Community College where students use the Albany NanoTech Institute of the Nanoscale Science and Engineering at the University of Albany for a portion of their training.

High School Outreach Programs. Many postsecondary nanotechnology programs include a high school outreach component. A wide variety of high school outreach efforts exist. The University of Pennsylvania collaboration sponsors a Nanotechnology High School Teaching Fellows program that recruits teachers to become "ambassadors and advocates in high schools." The Nanoscale Science and Engineering College at the University of Albany is partnering with Albany High School on an intensive "Nanohigh" pilot program that includes fellowships, scholarships, a two-week Nanotechnology Exploration program of instruction conducted at the College of Nano Science and Engineering, and other internship opportunities for high school students to join in nanotechnology research. In Austin, the Microelectronics Research Center at the University of Texas has hosted occasional groups of high school teachers and students, but currently lacks a regular, continuous, full-scale outreach program.

## Table 6. Selected Community College Programs in Nanotechnology

| Community College Location | Program / Credentials Offered | University Collaborators | Comments |
|---|---|---|---|
| North Seattle Community College - Seattle, Washington | Associate of Applied Science--Transfer Degree in Nanotechnology (AAS-T) | University of Washington | |
| Forsyth Technical Community College North Carolina Nanotechwire.com/news.asp?nid=115`&182&pg=5 | | Center for Nanotechnology and Molecular Materials Wake Forest University | |
| Central New Mexico Community College Albuquerque, New Mexico www.cnm.edu | | University of New Mexico and Sandia Labs | Includes focus on MEMS |
| Hudson Valley Community College Troy, NY | | College of Nanoscale Science and Engineering - University of Albany-SUNY | |
| Tulsa Community College Tulsa, Oklahoma http://www.tulsacc.edu | AAS Electronics with nano option, Nano Certificate | | |
| Five community colleges in Pennsylvania | AAS in Nanobiotechnology | The Nanotechnology Institute -- University of Pennsylvania and Drexel University http://www.nanotechinstitute.org/nti/workforceDevelopment.jsp | Developed five courses in nanobiotechnology taught in participating community colleges |
| 22 community colleges across Pennsylvania | AAS in Nanofabrication Manufacturing Technology and other variations | Center for Nanotechnology Education and Utilization, Pennsylvania State University http://www.cneu.psu.edu/edAcademicADP.html#top | Not all courses or programs are available on all community college campuses |
| Available to students in two-year colleges in Pennsylvania | Capstone Semester-Nanofabrication Manufacturing Technology (NMT) | Center for Nanotechnology Education and Utilization, Pennsylvania State University http://www.cneu.psu.edu/edAcademicCap.html | Also offers Nanotech Camps and Educator Programs |
| Normandale Community College, Bloomington, MN http://www.nr.cc.mn.us/academics/?dept=42 | AAS in Nanotechnology | | Emphasis on Vacuum Technology and Surface Science or Semiconductor Processing |

## Nanotechnology Education and Training Developments in Central Texas

### *University Resources*

The University of Texas has two major well equipped research facilities focused on nanotechnology: the Nano Science and Technology Building located on the main campus which houses the Center for Nano and Molecular Materials; and the Microelectronics Research Center, located at the J.J. Pickle Campus.

Recognizing the multi-disciplinary nature of nanotechnology, the University of Texas at Austin has taken an interdisciplinary approach to all its programs in Nanotechnology. For example, the portfolio nanotechnology program includes graduate students from eight science and engineering majors. The Graduate Portfolio Program in Nanoscience and Nanotechnology is a certification program, which provides an opportunity for doctoral students to obtain credentials in nanoscience and nanotechnology while they are completing the requirements for a doctoral degree in a particular discipline.

Participating students take four courses (12 semester hours) chosen from a list of courses approved by the Portfolio Committee. One of the four courses must be an introductory survey course on nanoscience and nanotechnology. In addition, students must prepare a research presentation involving nanotechnology and attend a weekly seminar. At the time of graduation, the student's transcript will reflect a certification that the student has completed the graduate portfolio in nanoscience and nanotechnology.

In addition, the University's Texas Materials Institute operates as an interdisciplinary "virtual department" to coordinate materials science and research program. Its thrust areas include nanomaterials and clean energy. The Institute sponsors interdisciplinary masters and doctoral education programs in materials science and engineering.

At the undergraduate level, the University of Texas has begun a Nano-Lab program for upper division students in engineering and natural sciences. Nano-Lab introduces upper-division students to nanoscale science and engineering concepts. Nano-Lab does not create a new course; rather students enrolled an existing courses in the participating departments are combined into interdisciplinary teams that spend one week on a nano-lab module involving nanotechnology. Also, through the interdisciplinary Science, Technology and Society program in the College of Liberal Arts faculty and undergraduate students are examining the societal impacts of nanotechnology.

Another postsecondary resource in the Central Texas area is the Nanomaterials Application Center at Texas State College in San Marcos. The Center operates a laboratory with research capabilities in nanotechnology and partners with private industry to expedite the commercialization of inventions in nanotechnology.

## Nanotechnology Activities at Austin Community College

As noted earlier, through the Department of Electronics and Advanced Technologies at Austin Community College, students can earn an Associate of Applied Science or a one-year Certificate in one of several specializations offered within the department. Electronics Technology degree plans center on a common core of 10 required electronics courses, plus 3 or 4 additional courses to complete one of seven specialized degrees. Currently, there is no specialization in Nanotechnology because there are not yet sufficient numbers of annual job openings in nanotechnology at the associate degree level to warrant establishing such a degree specialization. Nevertheless, ACC faculty has been active and involved in several key activities with respect to nanotechnology training in Texas. Two projects that illustrate this are the Nanaotechnology Curriculum Consortium and the Nanoelectronics Workforce Development Initiative.

### The Nanotechnology Curriculum Consortium in Texas

With three years of funding from the Texas Higher Education Coordinating Board, representatives from six Texas community colleges and technical schools developed the Nanotechnology Curriculum Consortium (Peterson et al, 2005). Dr. Raj Nagarajan represented Austin Community College in this project.

The project's goal was to identify the need for technicians in industries utilizing nanotechnology concepts in Texas. Through examination of existing programs and curricula, surveys, workshops, and interviews at five nanotechnology-related firms, project members sought to identify the skills and training required of nanotechnology technicians. This effort led to the development of six new workforce education courses, which were accepted into the Texas Workforce Education Course Manual (WECM). Also, the project made curriculum recommendations and resources for developing an Associate of Applied Science degree program in Nanotechnology (http://www.westtexas.tstc.edu/nano/index.cfm). The names of the six courses (hyperlinked to general learning objectives) are as follows:

NANO 1301 Introduction to Nanotechnology
NANO 1303 Nanotechnology Safety
NANO 2150 Nanotechnology Seminar
NANO 2325 Nanotechnology Materials
NANO 2326 Nanotechniques and Instrumentation
NANO 2486 Nanotechnology Internship

### The Nanoelectronics Workforce Development Initiative

In March 2006, SEMATECH and Austin Community College received a $4 million workforce development grant from the state of Texas for the Nanoelectronics Workforce Development Initiative. The aims of the project were to:

- “Provide a highly trained and innovative workforce to meet the growing needs of emerging technology companies in Texas;
- Develop leading edge curriculum and training materials; and
- Solidify Texas’ commitment to leadership in commercialization and innovation of revolutionary technology.”

The centerpiece of the two-year project was an internship program to place at least 160 students from Texas colleges into internships at SEMATECH. Students from associate level to PhD who were from Texas colleges and majoring in science, engineering and technical subjects were eligible to participate. The internships ran for periods of 3 months, 6 months or 9 months and were scheduled around school classes. Most students were concurrently enrolled in school taking courses while they were working. Student interns were paid $15 per hour for 20 hours per week. In addition, to encourage participation of students from outside of Central Texas, beginning in May 2007, re-locating students serving internships received a housing stipend of up to $500 per month.

Student interns were placed in three SEMATECH research and development organizations: Advanced Technologies Development Facility (ATDF), International

SEMATECH Manufacturing Initiative (ISMI), and SEMATECH itself. Most students worked at the ATDF, a for-profit subsidiary of SEMATECH that conducts research and development projects for member companies and others. Second, students worked at ISMI, which focuses on manufacturing productivity issues, simulation analysis, metrology and environmental issues. Third, some worked for SEMATECH itself in one its three technical divisions: Lithography, Interconnect and the Front-End Processing (FEP).

The interns were called "nanoscholars" because the semiconductor industry now produces semiconductors at the nanoscale level. As of October 2007, the Nanoscholar program had placed 163 students into internships (exceeding the target of 160), of whom 144 were from postsecondary institutions in central Texas. More than a third were community college students. Of the 57 students at the associate level who participated, 53 were from Austin Community College. Please see Appendix A for a list of the Nanoscholar placements for this program, compiled by Peter L. Marrone of SEMATECH. Appendix A lists each intern's degree type, major, college or university, position at SEMATECH, and duration of the internship.

Associate-level students were placed into positions as technicians, working with manufacturing equipment maintenance or facilities maintenance. Students at the bachelor's level tended to work in engineering; biotechnology majors worked on process characterization, becoming familiar with scanning electron microscopes and other tools they will use in biotechnology. Most graduate students served as interns on research teams.

All interns received three days of orientation, including training on safety and clean-room protocols. The remainder of their training was conducted on the job, under the guidance of mentors and managers. They also received specific training for their individual job assignments.

The internships offered more than simply opportunities for observation; they provided "hands-on" experience. At the beginning of the Nanoscholars program, several SEMATECH staff members were apprehensive about students breaking equipment or slowing down productivity. However, a few months into the pilot program, the apprehensions had disappeared and students were widely viewed as active contributors to the research work.

However, not all the interns worked directly with nanotechnology, nor did they learn much about nanotechnology in their internships. Many of the interns did receive an introduction to nanotechnology by attending a "Nano 101" workshop or the Statewide Conference on Nanotechnology in August 2007. However, the interns did not receive any common instruction to nanotechnology in their internships. When asked what he learned about nanotechnology in his internship, one student responded: "I gained an appreciation of why we have to be so careful in cleaning tools to prevent contamination of products that are so small."

The experience helped to qualify them for jobs in nanoelectronics, but not in other areas of nanotechnology. Many students found their Nanoscholar internship experience to be extremely valuable in learning about work and for obtaining employment in the semiconductor industry. Indeed, several former nanoscholars are now working for Austin-area semiconductor companies largely due to their experience in working at SEMATECH.

To date, no detailed systematic follow-up has been conducted on former Nanoscholars. The project manager at SEMATECH did contact all nanoscholars by email one month before the completion of their internships and asked to identify their future career plans. He reported that about 60 percent indicated they would return to school and other 40 percent said were entering the workforce. They also noted that they anticipated their participation in the Nanoscholar program would benefit them immensely in job interviews and make them more employable, having had experience in a real-world business environment.

The Nanoscholar program was part of a broader initiative aimed at enhancing understanding of nanotechnology in Texas. The project conducted series of forums for business leaders and educators across the state featuring workshops with an introductory program on nanotechnology called “Nano 101”, made presentations at annual Texas Nano conferences, and sponsored a statewide Nanotechnology Conference in Austin in August 2007.

In addition, the project developed curriculum materials to provide an introduction to nanotechnology and its applications. Twelve modules were authored by nanotechnology experts from across Texas and presented at the 2007 Statewide Conference:

1 *Introduction to Nanotechnology* by Alberto Quinonez
2 *Nanoelectronics: Top Down Fabrication* by Sanjay Banerjee
3 *Nano Bio & Chemical Processing: Bottom Up Fabrication* by Paul Barbara
4 *Nano-characterization and manipulator tools* by Ed Ardizoni
5 *Nano-Materials Applications* by Vicki L Colvin
6 *MEMS & NEMS* by Raj Nagarajan
7 *Nano-Defense Applications* by David Zubia
8 *Nano-Energy Applications* by Wade Adams
9 *Nano-Biotechnology Applications* by Linnea Fletcher
10 *Nanotechnology: Consumer Applications* by Kelly Kordzik
11 *Nanotechnology: Economic Development & Jobs* by Walt Trybula
12 *Nanotechnology: Environmental Impact & Societal Factors* by George Staff

By February 2008, the modules will be posted on a public worksite with encouragement to high school teachers to use them as resources for instruction. Together, the twelve modules are intended to form the basis of an introductory course in nanotechnology and its applications for use in high schools and community colleges.

**Key Issues for Workforce Development**

An overarching goal of workforce development activities is to help assure that as nanotechnology comes into wider use in production and manufacturing processes in Austin, the needs for skilled labor are understood and anticipated, and a pool of interested skilled workers is available.

*Despite dramatic claims regarding the impact of nanotechnology on the economy and employment, there are very limited numbers of nanotechnology technician jobs in Austin – currently and immediately projected. This situation means that it is difficult to “test out” training options.*

There is considerable student interest in nanotechnology, in part because nanotechnology offers hope to solve pressing world problems such as generating sustainable clean energy, improving medical diagnosis and therapy for cancer and other diseases, developing hydrogen automobiles, and others. Thus nanotechnology can become a vehicle to attract more young people to science, technology, engineering and mathematics (i.e., STEM subjects).

## Recommendations Going Forward

The Nanoelectronics Workforce Development Initiative provided a good foundation on which to build. SEMATECH and Austin Community College worked well as partners, according to testimony from both parties. The nanoscholar internships offered students more than opportunities for observation; they provided "hands-on" experience. The Nanoelectronics Workforce Development Initiative proved that nanotechnology internships were feasible in the research environment at SEMATECH and popular among students. At the beginning of the Nanoscholars program, several SEMATECH staff members were apprehensive about students breaking equipment or slowing down productivity. But a few months into the pilot program, the concerns had disappeared and students were widely viewed as active contributors to the research work.

*The Nanoscholar internship program offered workplace experience in a clean-room environment and helped prepare them for jobs in the semiconductor industry. Nanoscholar internships did not have any explicit learning objectives related to nanotechnology, did not provide an initial orientation to nanotechnology, nor were they evaluated on the basis of what students learned relevant to nanotechnology*.

Yet through workshops held across the state and through the statewide conference, the Initiative raised interest in nanotechnology.

If the program is continued, we make the following recommendations:

- The Nanoscholar internships should be modified to provide more explicit focus on nanotechnology. For example, all nanoscholars could be given with an introduction to nanotechnology, the program could have learning objectives related to nanotechnology, and part of its evaluation criteria could include what students learn related to nanotechnology. These changes could be accomplished while still maintaining a broader emphasis on fulfilling semiconductor industry needs. This may be easier to accomplish since SVTC Technologies has committed to purchased the ATDF by the end of 2007. SVTC Technologies plans to buy more advanced processing equipment for use by both semiconductor chipmakers and nanotech startups (Ladendorf, December 4, 2007 and December 9, 2007).

- ACC has opportunities to "put all the pieces together" through collaboration with SEMATECH and the nanotechnology resources at the University of Texas at Austin. SEMATECH can offer workplace experiences for students. Our review of nanotechnology programs in community colleges across the nation revealed that many of them operate in partnership with a local university. ACC and SEMATECH already have a working relationship through the Nanoelectronics Workforce Development Initiative.

Austin Community College has several options for moving forward with nanotechnology; namely:

1. Establish an introductory course on *Nanotechnology and its Applications*. This effort could make use of ACC's own Nano 101 workshop materials, the curricula produced by the Nanoelectronics Workforce Development Initiative, the Texas Nanotechnology Curriculum Consortium, as well as the voluminous introductory material available through the Internet. The course could also expose students to laboratory research, perhaps through the University of Texas facilities. The course could be team-taught. It could be made available on the Internet.

2. Offer the introductory nanotechnology course to reach high school teachers and students as part of a broader program of high school outreach. For example, the course could be offered to high school science teachers in summer workshops. ACC can build nanotechnology activities onto its existing general high school outreach efforts as well as specialized networks, such as the high school outreach program developed by the Department of Biotechnology.
3. Build examples from nanotechnology into ACC's existing science and technology courses where appropriate.
4. Following the interdisciplinary emphasis built into the University of Texas program, develop an interdisciplinary module focused on nanotechnology to be available as a "capstone" experience for students nearing completion of a program in related technology (e.g., electronics, biotechnology) or natural science (e.g., biology, chemistry, physics.)

As the labor market develops for electronics technicians with knowledge of nanotechnology, add an eighth specialization to the ACC Electronics curriculum with a sequence of courses in nanotechnology. Like the other specializations, the nanotechnology specialization should include an internship in industry. It could be designed to enhance the skills of existing students, as well incumbent workers with an interest in nanotechnology.

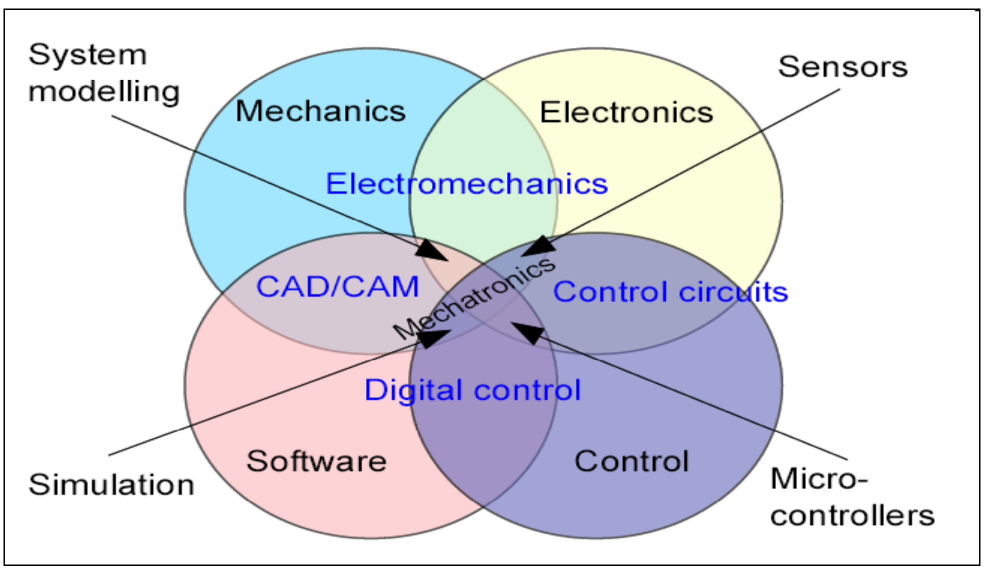
These activities would have two underlying objectives: (1) to introduce nanotechnology to a wider audience including high school teachers and especially to students to attract them to study STEM subjects; and (2) to add nanotechnology instruction as a supplement to existing programs, e.g., programs which train competent electronics technicians, biotechnicians, or medical technologists. Nanotechnology education would supplement or enhance—not supplant—existing programs.

# MECHATRONICS

> "Many existing jobs categories currently or will soon require Mechatronics skills and problem solving ability among workers who currently design, implement, manufacture, service, and repair a wide array of equipment. Mechatronics technicians are involved in robotics, automated manufacturing and packaging, automobiles, airplanes, gas pumps, vending, gaming, ATM machines, heating and cooling systems, and renewable energy systems."
>
> TSTC-Harlingen Mechatronics Technology Department

Mechatronics is a multi-skilling approach to training that integrates mechanical and electrical systems, control systems and information technology (Vanston et al, 2007, p. ix). The term *mechatronics* first appeared in the 1960s, created by combining the words "mechanics" and "electronics." When computers came into widespread use, informatics or intelligent computer control was added to the mix in the 1980s. Mechatronics requires cross-disciplinary knowledge and skills and does not fit neatly into the current structure of disciplines typically found in postsecondary education.

**Figure 6. An Illustration of the Transdisciplinary Nature of Mechatronics**




Source: Mechanical, Aerospace, and Nuclear Engineering Departments at Rensselaer Polytechnic Institute (2001) available at

http://commons.wikimedia.org/wike/Image:MechatronicsDiagram.svg

An additional complication in studying this subject is lack of agreement on a clear definition of mechatronics. Figure 5 illustrates the variety of definitions used in various colleges and the literature on mechatronics.

## Economic/Employment Factors and Job/Skills Outlook

According to a recent study by Texas State Technical College and Technology Futures, Inc, a significant demand for technicians trained in mechatronics exists in Texas. A statewide survey made in 2006 of 41 Texas manufacturing employers predicted their desire to hire 230 mechatronics technicians in the next 12 months and an estimated 400 over the next one to three years (Vanston et al, 2007, p. xii). Five of the larger employers — including three major semiconductor manufacturers — said they would hire at least 50 mechatronics-trained technicians in the next three years.

The same study identified a list of "companies that employ mechatronics principles in the delivery of good and services." In order to validate the TSTC results in Austin for the Manufacturing Skills Initiative project, researchers attempted to contact each of the eighteen names and firms identified in Austin. Please see Appendix B for the Mechatronics Survey Form.

The results were disappointing. Every contact except one was either an incorrect email address, did not respond, or responded by asking: "What is *mechatronics*?" **Only one respondent affirmed that his firm did mechatronics work.** This particular firm designed, built and installed automation equipment for packaging applications in a variety of Austin-area industrial firms. However, even that firm divided its mechatronics work so that technicians did the electro-mechanical work while engineers worked with the software and control systems. Thus, the full integrated mechatronics skill set was not used in the job of any single individual at this firm.

Although the term, *mechatronics* is widely used in Europe, Japan and Mexico, it is largely unfamiliar in Austin's advanced manufacturing sector. Indeed, to date we have been unable to find any Austin firm yet that uses the occupational title, "*mechatronics technician*."

**It is possible that Austin-area technicians are skilled in mechatronics without using the term**. For example, reportedly the skills required by semiconductor equipment technicians are similar to mechatronics. Thus, in order to investigate this issue further, we developed a survey of mechatronics topics. We began with the alphabetical list of topics taught in mechatronics courses in community college mechatronics programs across the country. Then we re-organized the list under topical headings and augmented it with assistance from Dr. Hector Aguilar of Austin Community College, including additional topics he suggested.

## Training/Development/Preparation for Mechatronics

Mechatronics is a growing interdisciplinary field in engineering colleges at American universities. Numerous universities offer courses in mechatronics at the undergraduate and graduate level. These courses cover a combination of mechanical engineering, electrical engineering, computer information, and information technology. Laboratory classes normally accompany these courses. Engineers focus on the design of mechatronic systems. The universities with mechatronics courses and activities include Cal Tech, Georgia Tech, Idaho State, Kettering University, MIT, Minnesota State, North Carolina State, Northwestern, Ohio State, Pennsylvania State, Purdue, Rensselaer Polytechnic Institute, San Jose State, Stanford, UC Berkeley, University of Illinois, University of Missouri, University of South Carolina, University of Tulsa, University of Utah, University of Washington, Virginia Tech, Texas A & M and the University of Texas at Austin.

Mechatronics is emerging in two-year colleges as well, but much more recently. Figure 7 shows a list of selected mechatronics programs in community colleges and technical schools. Nearly all were begun within the past two years and most were started with funding from grants from government and from local industry. The only Texas two-year program in *mechatronics technology* is in place at TSTC Harlingen. It began in fall 2006 with a laboratory of specialized equipment to teach mechatronics, financed by a $1 million grant from the National Science Foundation.

The programs at the ACC Department of Electronics and Advanced Technologies cover nearly all of the topics involved in mechatronics,[4] but the Department wants further confirmation on which topics local firms consider to be priorities. To date, we have received feedback that employers want practical training—not just theoretical instruction. Also, one employer pointed out that while electronics is well covered, mechanics receives less attention.

Effectively taught, mechatronics is not just a series of independent specialties. The various disciplines need to be taught and learned in an integrated or holistic way. Covering all the needed specialties and teaching them in an integrated way is a major challenge in a two-year curriculum. Integration can be achieved through working on projects in teams. For example, at Rensselaer Polytechnic, a mechanical engineering student is paired with an electrical engineering student to work on a project that requires the knowledge and skills of both of them. Internships and on-the-job experience can also be helpful. Required capstone projects or troubleshooting assignments that involve knowledge of several areas can also be helpful.

### Key Issues for Workforce Development

Austin companies do not commonly use the term "mechatronics" so it is difficult to capture information on employment and practices.

Attempts to conduct local validation of the TSTC study findings of Texas manufacturing employers identified as "employing mechatronics principles" yielded few local responses.

Information on local employer needs is sorely lacking, particularly about whether and to what extent mechatronics integration is already happening in Central Texas, and what those applications, processes, and skills actually "look like" and require of technicians.

ACC stands ready to develop responsive mechatronics training options, but cannot do so without input from employers about how these needs play.

[4] The only topics either not taught or required as prerequisites by the ACC Department are CNC Machine Maintenance, CNC Machine Programming, CNC Trouble Shooting, Hydraulics, Computer Integrated manufacturing (CIM), Computer Programming (C, C++, etc.), Computer-Aided Design (CAD), and Conventional Machining Fabrication.

**Figure 7. Definitions of "Mechatronics"**

Chico State University

"field of study that combines the fundamentals of Mechanical, Electrical, and Computer Engineering"

Clemson University

"the blending of software [and] hardware for the design [and] analysis of advanced control techniques"

*Design with Microprocessors for Mechanical Engineers* (book)

"science that integrates mechanical devices with electronic controls"

Industrial Research and Development Advisory Committee of the European Community

"synergistic combination of precision engineering, electronic control and systems thinking in the design of products and manufacturing processes."

*Introduction to Mechatronics and Measurement Systems* (book)

"the interdisciplinary field of engineering dealing with the design of products whose function relies on the integration of mechanical and electronic components coordinated by a control architecture."

Journal of Mechatronics

"the synergistic combination of precision mechanical engineering, electronic control and systems thinking in the design of products and manufacturing processes"

Loughborough University (United Kingdom)

"Mechatronics is a design philosophy that utilizes a synergistic integration of Mechanics, Electronics and Computer Technology (or IT) to produce enhanced products, processes or systems."

ME Magazine

"the synergistic use of precision engineering, control theory, computer science, and sensor and actuator technology to design improved products and processes"

"simply the application of the latest techniques in precision mechanical engineering, controls theory, computer science, and electronics to the design process to create more functional and adaptable products."

*Mechatronics - Electromechanics and Control mechanics* (book) "cross-disciplinary [field]

that simultaneously involves mechanics, electronics, and control of computer-integrated electromechanical systems"

*Mechatronics - Electronic Control Systems in Mechanical Engineering* (book) "integration of electronics, control engineering and mechanical engineering"

*Mechatronics - Electronics in products and processes* (book) "an integrating theme within the design process [combining] electronic engineering, computing and mechanical engineering"

*Mechatronics - Mechanical System Interfacing* (book) "the application of complex decision making to the operation of physical systems"

*Mechatronics Engineering* (book) "preplanned activity to consider electrical, mechanical, and software constraints over the product life cycle in a simultaneous manner early in the development process"

*Mechatronics System Design* (book) "methodology used for the optimal design of electromechanical products"

North Carolina State University Course

"the synergistic integration of precision mechanical engineering, electronic control and systems thinking in the design of intelligent products and process."

Definitions of Mechatronics (continued)

Rensselaer Polytechnic Institute

"the synergistic combination of mechanical engineering, electronics, control systems and computers--all integrated through the design process."

University of California at Berkeley

"a flexible, multi-technological approach in the integration of Mechanical Engineering, Computer Engineering, Electronics, and Information Sciences."

University of Linz

"technical systems operating mechanically with respect to at least some kernel functions but with more or less electronics supporting the mechanical parts decisively"

University of Washington

"the integrated study of the design of systems and products in which computation, mechanization, actuation, sensing, and control are designed together to achieve improved product quality and performance."

Virginia Polytechnic Institute

"Mechatronics is concerned with the blending of mechanical, electronic, software, and control theory engineering topics into a unified framework that enhances the design process."

Source: Compiled by Professor David Alciatore, Colorado State University
http://mechatronics.colostate.edu/definitions.html

### Table 7. Selected Community College Programs in Mechatronics, 2007

| | | | |
|---|---|---|---|
| Sierra Community College Sacramento, CA www.realskillsrealjobs.com | Program in Mechatronics | | Begun with $1.2 million in grants from State and match funding from local industry |
| Center for Automation and Motion Control Alexandria Technical College, Alexandria, MN | AAS Manufacturing Engineering Technician | Program focused on advanced packaging technologies | In partnership with local industry and European institutions |
| St Clair County Community College, MI www.sc4.edu/show.php?title=Mechatronics&category=Engineering%20Technology%20Department&mode=c&ps=y&year=0708 | AAAS in Mechatronics | | |
| Central Carolina Community College Lee County, North Carolina http://www.cccc.edu/programs/mechatronics/html | Mechatronic Systems Associate | | |
| Clinton Community College Clinton, Iowa | Diploma, Mechatronics Technician; AAS, Mechatronics Technology | | Supported by a $366,000 state grant |
| Suffolk County Community College Long Island, NY | AAS (in process) | Mechatronics Education Center focuses on Advanced Manufacturing | Funded by a $2.38 million grant from the U.S. Department of Labor |
| Nebraska Mechatronics Education Center Central Community College, Columbus NE http://www.mechatronics-mec.org/ | AAS (in process) | Collaborative effort among six Nebraska community Colleges, three four-year universities, government and businesses | Supported by $3 million in grants, half from the Community College System and half from local employers |

## RECOMMENDATIONS GOING FORWARD

Determine if there are other avenues or industry partnerships that could be explored to obtain the needed information about mechatronics. For example, Task Force members — perhaps with ACC and the Chamber in the lead, in partnership with WorkSource — could jointly sponsor an information session on mechatronics and how other communities are responding. Representatives who come to the session could be asked to respond to the Mechatronics Skills survey and further assessment could be made about how to determine clear channels of communication between companies where mechatronics practices are emerging, and training providers such as ACC that want to be proactive with program development.

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Burnette, Cliff, Human Resources, Spansion, Personal interview by Robert Glover and Suzanne Hershey, June 18, 2007.

Davenport, Susan, Vice President, Business Expansion and Retention, Greater Austin Chamber of Commerce, Telephone interview by Suzanne Hershey, April 16, 2007.

Evans, Eliza, Director of Research, $IC^2$, Personal interview by Robert Glover, April 23, 2007.

Floyd, Bill, Vice President/General Manager, Southwest Division, Manpower, Inc., July 5, 2007.

Floyd, Randy. Director, Office of Contingent Workforce, Freescale, Personal interview by Robert Glover and Suzanne Hershey, June 19, 2007.

Gold, Aliza, Project Coordinator, Digital Media Collaboratory, IC$^2$, Personal interview by Robert Glover, June 20, 2007

Hagan, Alisa, Senior Human Resources Manager, Spansion. Telephone interview by Suzanne Hershey, July 3, 2007

Jackobs, Steven. Executive Director, Capital IDEA, Personal interview by Robert Glover, May 1, 2007.

Marone, Peter, Special Projects Manager, SEMATECH. Personal Interview by Robert Glover, October 17, 2007.

Midgley, Dr, Michael, Vice President, Workforce Programs, Austin Community College, Personal interview by Robert Glover and Suzanne Hershey, April 11, 2007.

Modesty, Ron, Employer Coordinator, Capital IDEA, Personal interview by Robert Glover. May 1, 2007.

Serda, Julian, Training Department, Spansion, Telephone interview by Robert Glover, October 2 and 10, 2007.

Tracy, Donald, Employee Partners, Personal interviews by Robert Glover, Suzanne Hershey and Blanca Alvarado, April 18, June 19, and July 5, 2007.

### Selected Useful Websites

Bureau of Labor Statistics (http://www.bls.gov)

Career Voyages (http://www.careervoyages.gov/)
This website is a collaboration of the U.S. Department of Education and the U.S. Department of Labor. On the left margin is the gateway to information on advanced manufacturing, biotechnology, and nanotechnology.

Council on Competitiveness (http://www.compete.org/)

Greater Austin Chamber of Commerce (GACC) (http://www.austin-chamber.org)

National Association of Manufacturers (http://www.nam.org)

National Center for Learning and Teaching in Nanoscale Science and Engineering
http://www.nano.gov/

National Nanotechnology Initiative http://www.nanoed.org/

Rural Capital Area Workforce Development Board
(http://www.ruralcapitalworkforce.com/)

Texas Economic Development Cluster Initiative
(http://www.twc.state.tx.us/news/ticluster.html)

Texas Workforce Commission, Labor Market Information, TRACER
(http://www.tracer2.com/)

*Work*Source (http://www.WorkSourceaustin.com)

# APPENDICES

Appendix A: Job Postings from Semiconductor Companies in Austin, June 2007

Appendix B: Semiconductor Job Postings in Austin from Staffing Agencies, June 2007

Appendix C: Nanotechnology Companies and Job Postings in Austin, May 2007

Appendix D: Listing of Nanoscholar Placements: March 2006 to October 2007

Appendix E: Mechatronics Survey Form

## APPENDIX A: JOB POSTINGS FROM SEMICONDUCTOR COMPANIES IN AUSTIN, JUNE 2007

| Largest Semiconductor Companies Listed by Total Employment in Austin (Number of employees reported ranged from 5,500 to 150 employees) | | | |
|---|---|---|---|
| **Company Name** | **Job Openings** | **Job Description/Requirements** | **Key Skills/Responsibilities** |
| **Freescale Semiconductor**<br><br>http://www.freescale.com/<br><br>Employment: 5,500<br>Source: Chamber | **Title** OH Site Services Multi-Ops Semiconductor Maintenance Technician **Job Category** Other Non-technical Positions<br><br>**1 position** | **Required Education** Unknown **Required Experience** Unknown **Department Description** OH Site Services Operations and Maintenance is responsible for operating, maintaining, repairing and troubleshooting "all" site facility systems. | **Scope of Responsibilities/Expectations** Operates, maintains, installs, repairs, and troubleshoots "all" site facilities systems. Operates and maintains site FMCS and BAS automation systems. Performs preventative, predictive, and RCM maintenance on "all" site facilities systems. Must work across "all" specialties/disciplines in performance of PMs, corrective maintenance, trouble calls, design, project management, system startup and commissioning, vendor interface, contract coordination, and inspection activities. Participates in technical training in advanced technical areas. Maintains and updates operating procedures.<br>May perform preventative maintenance functions on toxic gas monitoring controllers, centrifugal pump repair, alignment and replacement, vibration analysis and boiler tuning. May oversee boiler preventive maintenance annuals and chiller preventive maintenance annuals. May apply and interpret predictive maintenance concepts including, thermographic inspection, mechanical and electrical oil analysis, vibration analysis, eddy current testing. May perform instrumentation calibration, installation and troubleshooting of electronic devices such as temperature transmitters, humidity transmitters and level controllers. May perform a wide range of low, medium, and high voltage electrical maintenance installations and troubleshooting.<br>**Specific Knowledge/Skills** Minimum of 3 years of semiconductor trades or industrial maintenance/construction experience |
| **Applied Materials**<br><br>http://www.appliedmaterials.com/careers/job_search.html?menuID=5<br><br>Employment: 2,500<br>Source: Chamber | Engineering Technician<br><br>**3 positions** | **Required Knowledge & Experience:** Requires basic skills in problem solving, communication, personal effectiveness, team skills and quality. Requires basic knowledge of systems and software necessary to perform job function such as Lotus Notes, MS Word, Excel, and/or Fracas. Ability to work flexible hours and overtime as needed. - AS level degree in electronics technology or equivalent and 1-2 years directly related experience; or - BSEET level degree and 0-1 year directly related exp. | **Job Specific Knowledge & Experience:** - 2+ years directly related exp.; Previous exp. on Applied Materials` equipment.<br>**Responsibilities:** Works from test procedures and mechanical schematics, diagrams, written and/or verbal descriptions, and layouts to perform testing, checkout, and troubleshooting functions. Performs moderately complex mechanical, soldering, and repair tasks. Provides input to test procedures; may write simple technical reports and test procedures. Performs operational test and fault isolation on systems and equipment. Assists in determining methods or actions to remedy malfunctions. Assists in the design, test, and check-out of test equipment. Incumbents may be assigned to work in a lab environment performing activities including PM preparation, uptime monitoring, system safety checks, facility monitoring/setup, FSR planning and follow through, and/or engineering parts installation / tracking. |
| **Advanced Micro Devices (AMD)**<br><br>http://careers.amd.com/en-us/default.aspx<br><br>Employment: 2,300<br>Source: Chamber | Electronic Maintenance Technician 1<br><br>**1 position** | Associate's degree in electronics technology or equivalent combination of experience and training. A minimum of 1 year industry related experience is required for this position.<br><br>PRIMARY PURPOSE:<br>Assists in the troubleshooting of HST and SLT systems, both on the DUT tray / motherboard level and system level. Performs repairs as necessary. | KEY FUNCTIONS:<br>1. Learns to use diagnostic and product test programs to diagnose and repair HST and SLT equipment.<br>2. Makes use of oscilloscopes, digital voltmeters, and various other diagnostic equipment to diagnose and repair equipment failures at the DUT specific hardware level and system level specific to HST and SLT systems.<br>3. Participate in the building, and test validation of sub-assembly hardware associated with HST and SLT activities.<br>4. Receive training to maintain refrigeration systems associated with HST and SLT systems.<br>5. Is capable of performing duties with minimal to no supervision. |

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|---|---|---|---|
| **Company Name** | **Job Openings** | **Job Description/Requirements** | **Key Skills/Responsibilities** |
| **Samsung Austin Semiconductor**<br><br>http://www.sas.samsung.com/opportunties.html<br><br>Employment: 1,250<br>Source: Chamber | Engineering Technician (All Levels, Implant)<br><br>TX - Austin<br>Years Experience: 8-10 years<br><br>**8 different technician positions** | We currently seeking Engineering Technicians in our Implant area. This position is for Samsung Austin Seminconductor's current 200mm fab. Minimum 2 years related experience OR Military technical training/experience in a technical area (Nuclear Technician, Avionics, etc); 3-7 years related experience normally required; Education/Experience: Associates Degree or equivalent Military experience/training; Requirements: Expertise in Manufacturing - Semiconductor, Technician – Manufacturing. | Requires technician experience and the ability to read and interpret engineering specifications, maintenance manuals and engineering sketches. Semiconductor production experience a plus. Must be able to utilize complicated drawings and specifications as wells as a variety of precision measuring instruments. Reliable and punctual attendance is required. Candidate should be flexible with shift assignments and be willing to provide references.<br>Skills, Experience, Software, Knowledge and Toolsets<br>Experience on Varian and/or Axcelis GSD/HE Implanters within the last two years preferred.<br>Works on assignments that are moderately complex in nature where judgment is required in resolving problems and making routine recommendations. Normally receives no instructions on routine work, general instruction on new assignments. |
| **Solectron Texas, L P**<br><br>http://www.solectron.com/careers/careers.htm<br><br>Employment: 1,200<br>Source: Hoover's D&B | Production Test Technician 2<br>Full Time Employee<br>Hourly<br>posted 1/19/2007<br>Austin, TX | Requirements<br>GENERAL PURPOSE OF JOB:<br>Conducts, tests and troubleshoots electronic product, components and systems to ensure production quality standards are met.<br><br>Education / Experience<br>Typically requires a minimum of an Associates degree, military technical training or equivalent experience and training. In addition, typically requires 2-4 years of related experience. | ESSENTIAL DUTIES AND RESPONSIBILITIES TYPICAL FOR MOST POSITIONS:<br>1. Develops, maintains and improves all test and burn-in processes within area or responsibility.<br>2. Periodically reviews all process specifications to determine if they accurately reflect the process requirements and test techniques. Updates the specifications as required.<br>3. Ensures that test and burn-in processes are within all safety, ISO-9000 and BABT compliance<br>4. Consistently reviews quality yields and develops corrective actions to eliminate any yield detractors, further improves the process and product reliability. Works with the Quality Engineer to determine if field/box line data indicates a need for process/product improvement.<br>5. Assists with the fabrication and development of new equipment, fixtures and test programs.<br>6. Ensures that effective preventive maintenance, calibration, diagnostics, re-qualification and daily measurement schedules are in place for each test and burn-in process.<br>7. Coordinates manufacturing, maintenance and engineering preventive maintenance activities. Ensures that scheduled preventive maintenance activities are completed.<br>8. Assists engineering and the development labs with all new product introduction.<br>9. Coordinates and monitors all FIMPA or product off-load activities for assigned test.<br>10. Ensures that each test and burn-in process has a training/certification package for both manufacturing and maintenance. Facilitates the completion of these training/certification packages with the appropriate engineer(s) and the Resource Development Department.<br>11. Assists Industrial Engineering with all equipment moves or line re-arrangements as required.<br>12. Periodically evaluates new equipment and develops a realistic and cost effective capitol justification for purchasing this equipment.<br>13. Drives recovery actions/repair of any test or burn-in process that is down. Coordinates recovery/repair activities with the respective maintenance, TECHNICIANS, engineers, suppliers or maintenance spare parts analyzers whose area of competence is necessary to get the process back in working order.<br>14. Coordinates the development of disaster recovery plans for each test and burn-in process.<br>15. Follows Engineering test processes.<br>16. Ability to perform high-level repair, format and "build" software per unit configuration and connect hardware (cables) between multiple units and by nets. |

| Largest Semiconductor Companies Listed by Total Employment in Austin<br>(Number of employees reported ranged from 5,500 to 150 employees) | | | |
|---|---|---|---|
| **Company Name** | **Job Openings** | **Job Description/Requirements** | **Key Skills/Responsibilities** |
| **Solectron Texas, L P**<br><br>http://www.solectron.com/careers/careers.htm<br><br>Employment: 1,200<br>Source: Hoover's D&B | Line Maintenance Technician Full Time Employee Hourly posted 11/8/2006 Austin, TX<br><br>**1 position** | Requirements<br>GENERAL PURPOSE OF JOB:<br>Mechanical: Repairs and maintains machinery and mechanical equipment such as conveyor systems and production machines and equipment.<br>Electrical: Maintains and troubleshoots in-circuit and functional testers, associated test fixtures, stress chambers and chamber racks to ensure manufacturing test equipment is on-line.<br><br>Education / Experience<br>Typically requires an Associates degree in related field, military technical training or equivalent education and training. Typically requires 5 years of related experience and/or trade knowledge. | ESSENTIAL DUTIES AND RESPONSIBILITIES TYPICAL FOR MOST POSITIONS:<br>1. Through troubleshooting, identifies machine malfunctions and isolates the failure mechanism.<br>2. Repairs the failure mechanism in the most cost-effective manner.<br>3. Performs preventive maintenance at specified intervals and schedules.<br>4. Performs calibrations and re-qualifications on equipment at specified intervals and schedules.<br>5. Assists process technicians and engineers with the installation and removal of process equipment.<br>6. Analyzes and implements corrective action reports and process tracking mechanisms.<br>7. Records times and problems in equipment logs.<br>8. Provides daily equipment functioning activity information.<br>9. Sets up standard and special purpose laboratory equipment to test, evaluate and calibrate other instruments and test equipment.<br>10. Disassembles instruments and equipment and inspects components for defects.<br>11. Aligns, repairs, replaces and balances component parts and circuitry.<br>12. Devises formulas to solve problems in measurements and calibrations.<br>13. Assists engineers in formulating test, calibration, repair and evaluation plans and procedures to maintain precision accuracy of measuring, recording and indicating instruments and equipment.<br>14. May require travel to other Solectron sites or equipment vendors' locations.<br>15. Highest level may perform both software and hardware maintenance.<br><br>Knowledge / Skills / Abilities<br>Demonstrates advanced technical skills which may be used to conduct on-the-job training and/or lead/guide other employees. Demonstrates broad knowledge of functional techniques and has input to process improvement. Has awareness of and may apply new technologies. Proven ability of successfully communicating with internal and external parties. Must have a thorough knowledge of the maintenance of complex manufacturing process equipment. Requires the ability to utilize complicated drawings and specifications, and train others. Requires the ability to read and interpret blueprints, maintenance manuals and engineering sketches, and utilize complicated drawings and specifications, advanced mathematics and a variety of precision measuring instruments. |
| **Spansion**<br><br>http://www.spansion.com/about/careers.html<br><br>Employment: 1,000<br>Source: Chamber | SENIOR MANU-FACTURING TECHNICIAN<br><br>**3 positions** | Requirements: AA degree with emphasis on electronics, mechanical engineering, physics, chemistry, or equivalent technical training or experience. A good comprehension of core sciences and prior experience with semiconductor equipment maintenance or process engineering may substitute for a degree requirement. Ability to read complex technical written and verbal instructions. | Must be able to demonstrate strong interpersonal skills including effective problem solving ability, good communications, strong leadership and teamwork skills. Job Description Working within a natural work group (NWG), with minimal supervision, monitors and maintains process/test equipment, performing routine and complex set-ups, preventative maintenance, repair and modification. Under technical direction, responsibilities also include experimentation and documentation related to process/test execution. |

| Largest Semiconductor Companies Listed by Total Employment in Austin (Number of employees reported ranged from 5,500 to 150 employees) | | | |
|---|---|---|---|
| **Company Name** | **Job Openings** | **Job Description / Requirements** | **Key Skills / Responsibilities** |
| **Intel Corp. Texas Design Center**<br><br>http://www.intel.com/jobs/jobsearch/index.htm<br><br>Employment: 700<br>Source: Chamber | There are currently no positions available for the job categories: Facilities and Site Services; Manufacturing in Austin or TX | | |
| **Q Logic**<br><br>http://www.qlogic.com/careers/<br><br>Employment: 624<br>Source: Semi | Your search for: technician/ operator returned 0 matching record(s). | | |
| **Silicon Laboratories**<br><br>http://www.silabs.com/tgwWebApp/public/web_content/coinfo/careers/en/index.htm<br><br>Employment: 502<br>Source: Chamber | To search for career opportunities at one of these locations, please visit our Silicon Laboratories Career Website | | |
| **Martin- Decker Totco, Inc**<br><br>http://www.nov.com/jobs/NOVJobPostings.aspx<br><br>Employment: 450<br>Source: Hoover's D&B | No positions in the Austin area. | | |

**Largest Semiconductor Companies Listed by Total Employment in Austin**
**(Number of employees reported ranged from 5,500 to 150 employees)**

| Company Name | Job Openings | Job Description / Requirements | Key Skills / Responsibilities |
|---|---|---|---|
| **SEMATECH**<br><br>http://www.sematech.org/cgi-bin/careers.cgi<br><br>Employment: 420<br>Source: Chamber | There are no SEMATECH openings at this time | National research consortium | |
| **Tokyo Electron America**<br><br>http://www.tel.com/eng/careers/index.htm<br><br>Employment: 400<br>Source: Chamber | Job Title: Start-Up Engineer Employment<br><br>This position travels 100% supporting equipment installations at our US customer locations. | PRIMARY FUNCTION:<br>Performs on-site installation of semi-conductor processing equipment at customer facilities. Duties include technical assistance, status reporting, customer interaction.<br><br>MINIMUM QUALIFICATIONS AND EXPERIENCE:<br><br>-Associates degree in electronics, engineering, or other applicable field of study. (Bachelors Degree in Engineering or Technology preferred)<br>-Previous experience in maintenance, repair, and troubleshooting of semiconductor capital equipment - prefer Photolithography experience. | KEY TASKS/RESPONSIBILITIES:<br>-Performs on-site installation of semi-conductor processing equipment.<br>-Troubleshoots equipment problems; maintains records and reports as required; coordinates activities with peers, supervisor(s) and customers to minimize equipment downtime and interruptions; orders and installs parts; responds to emergency service calls as required; and, instructs customer operating technicians on system operation and maintenance.<br>-Perform upgrades and modifications to equipment as needed.<br>-Remain current on equipment/tools through appropriate training, manuals, factory periodicals, and other relevant materials. Incumbents are responsible for the upkeep, maintenance and security of company property including vehicles, tools, etc.<br>-Job duties are often performed in confined areas in a clean room environment, in awkward positions and/or in high places.<br>-Mechanical aptitude, manual dexterity and ability to lift/carry objects up to 50 pounds is required. Some positions may require the use of Personal Protective Equipment and proper industry safety procedures when working with one or more dangerous element or conditions such as chemicals, electric currents or high voltage, moving mechanical parts, radiation, etc.<br>-This position is primarily a traveling position that will require heavy overnight travel to the TEL factory, training facilities and/or customer locations. |
| **Sun Microsystems**<br><br>http://www.sun.com/corp_emp/indexus.html<br><br>Employment: 400<br>Source: Chamber | Technician/Operator:<br>There are no jobs that match the search criteria at this time | Some academic majors are ideally suited to specific divisions within Sun; from BA/BS to Ph.D. | |

| Largest Semiconductor Companies Listed by Total Employment in Austin (Number of employees reported ranged from 5,500 to 150 employees) | | | |
|---|---|---|---|
| **Company Name** | **Job Openings** | **Job Description/Requirements** | **Key Skills/Responsibilities** |
| **Cypress Semiconductor**<br><br>http://www.cypress.com/index.html<br><br>Employment: 325<br>Source: Chamber | No jobs matched the query; technicians or operators | | |
| **Cirrus Logic**<br><br>http://www.cirrus.com/en/careers/<br><br>Employment: 305<br>Source: Chamber | Your search found **0** matching jobs; for technicians | | |
| **SigmaTel**<br><br>http://www.sigmatel.com/<br><br>Employment: 300<br>Source: Chamber/Semi | Your search for: technician/ operator returned 0 matching record(s). | | |
| **Capital Spectrum**<br><br>http://www.capspec.com/index.html<br><br>Employment: 200<br>Source: Chamber | Do not advertise employment on website | | |
| **Celestica Corp.**<br><br>http://www.celestica.com/Careers/Framed/Careers.aspx<br><br>Employment: 200<br>Source: Chamber | There are currently no positions available. | | |

**Largest Semiconductor Companies Listed by Total Employment in Austin**
**(Number of employees reported ranged from 5,500 to 150 employees)**

| Company Name | Job Openings | Job Description/Requirements | Key Skills/Responsibilities |
|---|---|---|---|
| **Tyrex Group Ltd**<br>http://www.tyrexmfg.com/<br><br>Employment: 250<br>Source: Hoover's D&B | There are currently no available openings at TyRex Group, Ltd. | | |
| **Advanced Technology Development Facility**<br>http://www.atdf.com/cgi-bin/careers.cgi<br><br>Employment: 185<br>Source: Chamber | There are no ATDF openings at this time | We have a few openings for highly qualified, experienced individuals—not for technicians or operators. | |
| **Symmetricom**<br><br>http://www.symmetricom.com/About_Us/Careers<br><br>Employment: 180<br>Source: Chamber | No openings for technicians or operators on website. | | |
| **Active Power, Inc. [NASDAQ (GM): ACPW**<br><br>http://www.activepower.com/about-us/careers.html<br><br>Employment: 164<br>Source: Hoover's D&B | Nothing for technician or operator | Sales & Marketing: Project Engineer<br><br>Rep Channel Manager<br><br>Director of Sales - Various locations<br><br>Direct Sales - West | |
| **Qualcomm**<br><br>http://www.qualcomm.com/careers/<br><br>Employment: 152<br>Source: Chamber | Job(s) not found for technician or Operator | | |

## APPENDIX B: SEMICONDUCTOR JOB POSTINGS IN AUSTIN FROM STAFFING AGENCIES, JUNE 2007

| Agency Name | Positions looking to fill / Job Categories | Other Information |
|---|---|---|
| **Adecco** | Technician<br><br>Technology; Manufacturing/Operations<br><br>Adecco, the global leader in staffing solutions, has an immediate opening for a Technician with one of our largest clients. | Position Type: Temporary<br>Wages: $15.00 - $17.00 Hourly<br>Experience: 1-2 Years Experience<br>Desired Education Level: Associates<br>Date Posted: June 6, 2007<br>-The position is expected to last for up to 1 year. The opening is on second shift and works Monday to Friday with occasional weekends.<br>-Technicians perform facilitization, calibration, testing, and troubleshooting on the wafer fabrication machinery.<br>-Technicians may lead and advise the mechanical assemblers in the construction of the fab machines, helping perform large-scale mechanical assembly, putting together large parts using large tools to construct machines.<br>-Technicians work exclusively in the cleanroom environment.<br>-Typical shift hours are 4:45 p.m. " 2:45 a.m. |
| **Manpower**<br><br>Manpower is accepting applications for long-term contract positions with one of the most exciting companies to work for in Austin. | (ENTRY LEVEL) SEMICONDUCTOR WAFER FAB OPERATORS | Primary Skills: inspection; operator; semiconductor; wafer fab; cleanroom<br>Job Industry: Semiconductors<br>**Vacancies: 15**<br>Job City: Austin<br>Salary: $10/HOURLY To $12/HOURLY<br>Hours per Week: 42<br>Start Date: 06/15/2007<br>Job Duration: 12+ months<br>Detailed Job Duration: up to 12 months<br>Degree Type: HS<br>Experience Minimum: 2 Years |
| **Manpower**<br>To be considered for position you must answer online questionnaire and post resume at: us.manpower.com/j2c | SEMICONDUCTOR WAFER FAB OPERATORS | Primary Skills: cleanroom; operator; semiconductor; wafer fab; inspection<br>Job Industry: Semiconductors<br>**Vacancies: 20**<br>Job City: Austin<br>Salary: $10/HOURLY To $12/HOURLY<br>Hours per Week: 42<br>Start Date: 07/17/2007<br>Job Duration: 12+ months<br>Detailed Job Duration: up to 12 months<br>Degree Type: HS<br>Degree Area: NA<br>Experience Minimum: 2 Years |

| Agency Name | Positions looking to fill / Job Categories | Other Information |
|---|---|---|
| **Belcan Corporation** | Assembly Operator I | JOB SUMMARY: Entry level position for operation of clean room equipment as designated by the department supervisor. Responsible for cross-training on assembly/cleanroom functions, as required. This includes, but is not limited to, die attach, wire bond, bond pull, PIND, plasma clean, and seal. Operators may be required to operate multiple work stations, as needed.<br><br>Looking for candidates with experience working with micro electronics components. Level three solder experience helpful.<br><br>Provides full-service engineering, design and build, application technology, technical and temporary staffing, information technology, and multimedia services worldwide. |
| **Volt** | Wafer Fab Operator-Night Shifts Available<br><br>A leading semiconductor company in southeast Austin (Oltorf & Montopolis area) is immediately seeking Wafer Fab Operators, Test & Final Test positions for all shifts. | Operators are responsible for the production of integrated circuits using masking, diffusion and thin film processes.<br>These are 1-year contract positions with long-term employment opportunities. Employees will be working in a state-of-the-art clean room and will be trained to operate automatic and semiautomatic equipment used in microchip manufacture and/or assembly/test.<br>Work 4 days/nights first week, then 3 days/nights the second week. B Shift ($12.43/hr): 7pm-7am Sun, Mon, Tue, every other Sat D Shift ($12.65/hr): 7pm-7am Thurs, Fri, Sat, every other Sat., plus a $50 Referral bonuses!<br>**Requirements:**<br>• High school graduate or equivalent. • Manufacturing experience a plus, but not required (for Operator positions). • A stable job history, reliability, and a desire to work & succeed is most important. This is a fast-paced, accurate, detailed, on-your-feet position. • For Test & Final Test positions: 6 months to 1 year of clean room experience is required.<br>**Type:** CONTRACT; **Duration:** 365+ Days |
| **Volt** | Test Operators | A Fortune 500 semiconductor company in southeast Austin is immediately seeking Test Operators for a 1-year contract position. This position entails:<br>- Performs integrated circuit (IC) testing.<br>- Determines test results, records data in computer.<br>- Segregates ICs according to test results.<br>- Track sample lots through process.<br>- Maintain inventory trackers.<br>**Schedule: (Please note the hours!)**<br>12-hour compression shifts:<br>1st week - Saturday & Sunday 6am - 6pm, Tuesday 6pm -6am<br>2nd week - Saturday & Sunday 6am - 6pm, Wednesday & Thursday 6pm - 6am.<br>**Requirements:**<br>- IC testing experience a big plus.<br>- Knowledge of computer hardware.<br>- Knowledge of MS Outlook, Excel and Word.<br>- Able to pass extensive criminal background and drug screens.<br>**Type:** CONTRACT; **Duration:** 180 - 365 Days; **Payrate:** $10.00 - $11.00 Hourly; **Contact:** Volt Services |

| Agency Name | Positions looking to fill / Job Categories | Other Information |
|---|---|---|
| **Volt** | Wafer Fab Operator | These are 1-year contract positions with long-term employment opportunities. Employees will be working in a state-of-the-art clean room and will be trained to operate automatic and semiautomatic equipment used in microchip manufacture and/or assembly/test.<br><br>KEY FUNCTIONS: Sets-up or assists in the set-up of work stations. Performs specific production processes through the utilization of specs and ECN's. Maintains accurate records of water flow, mask levels and rejects. Understand safety rules and various chemical agents used at work station. May assist in training less experienced personnel. Perform other duties as assigned.<br><br>REQUIREMENTS: High school graduate or equivalent. Manufacturing experience a plus, but not required (for Operator positions). A stable job history, reliability, and a desire to work & succeed is most important. This is a fast-paced, accurate, detailed, on-your-feet position. Must be able to pass extensive criminal background & drug screenings.<br><br>SCHEDULES: 12-hr compressed shift schedules (e.g., 7am-7pm or 7pm-7am). Work 4 days/nights first week, then 3 days/nights the second week.<br>A Shift ($11/hr): 7am-7pm Sun, Mon, Tue, every other Wed<br>B Shift ($12.43/hr): 7pm-7am Sun, Mon, Tue, every other Sat<br>C Shift ($11/hr): 7am-7pm Thurs, Fri, Sat, every other Wed<br>D Shift ($12.65/hr):7pm-7am Thurs, Fri, Sat, every other Sat |
| **Volt** | Test Technician II | D2 SHIFT? Wed ? Sat 6 AM ? 6 PM has every other Sat. off. 4 days on 3 days off, then 3 days on 4 days off. Support multiple semiconductor lithographic fabrication processes including: resist coat, exposure, develop and inspection. Complete designed experiments, troubleshoot process problems, document processes, disposition wafer lots and assist in operator training. The successful candidate must posses strong problem solving, excellent communication, strong teamwork, ability to work without supervision and strong time management skills. Work will be in a wafer fabrication facility, including lifting and standing requirements, working with chemicals, some overtime required, some travel may be necessary. Requirements: A semiconductor device processing background is required. Experience with GaAs fabrication technology, especially photo and electron-beam lithography, is a plus. Experience with standard metrology tools is a must including profilometry, ellipsometry, reflectometry and optical microscopy. Experience using scanning electron microscope is preferred. Literacy with computer programs such as Microsoft Word and Excel is required. Good teaming, organizational and problem solving skills are required. Applicant must be a self-starter capable of troubleshooting problems by designing and executing experiments and analyzing the results. EDUCATION Associates degree is preferred. A minimum of five (5) years experience in semiconductor fabrication is required. Candidates without an Associates degree will be considered based on years of experience. Type: CONTRACT Duration: Temp to Hire Pay rate: $15.87 - $21.15 |

Source: Retrieved from
http://www.simplyhired.com/index.php?ds=sr&q=operator&l=austin%2C+tx&cy=AUSTIN&st=TX&z=78763&sw=semiconductor&x=0&y=0
on June 27, 2007. Using the following terms: Semiconductor and Austin

## Appendix C: Nanotechnology Companies and Job Postings in Austin, May 2007 [5]

| Company Name (12) | Description | Employment<br>(24 current positions)—as of 5-3-07 |
|---|---|---|
| NanoTox, Inc. | Nanotox provides unique, cost-effective toxicological tests and safety screening platforms that are effective and essential for nanotechnology design and engineering. This process allows the nanotechnology industry to safely introduce products with interfaces to human and environmental health. | "If you like to know more about nanoTox and opportunities within our company, please contact us." Retrieved from, http://www.nanotox.com/index2.html, on May 3. 2007.<br><br>0 |
| Nano Science Diagnostics, Inc. (NSD) | Nano Science Diagnostics (NSD) is an Austin company focused on delivering nanotechnology based innovative diagnostics products. NSD's products will be based on its key accomplishments in the area of biotagging of fluorescent nanoparticles, Point Of Care Tests (POCTs) for Medical diagnostics, and Rapid test for Food testing. | Take directly from their website: "NSD is looking for professionals with a Biochemistry & Diagnostics background."<br><br>Senior Scientist<br>Ph.D in Biochemistry with 10 years or more experience in industry or a research lab.<br>Junior Scientist<br>Ph.D in Biochemistry with at least 5 years of experience in industry or a research lab.<br>Lab Technician<br>BS/MS in Biochemistry with 3 years or more experience in industry or a research lab.<br>3 |
| Nano Master, Inc. | Nano-Master is a privately owned, sales, marketing, and engineering services organization specializing in design and manufacturing primarily for R&D and MEMS markets as well as representation through sales, service, and marketing. **H**eadquarters are located in Austin, near SEMATECH and AMD Fab 25, and it is equipped with a class 100 clean demo facility and class 10 pump refurbish facilities. | **Process Development Engineer position-**<br>Must have a minimum of 4 years engineering degree. Experience in plasma processing, sputtering, or chemical cleaning is desired. Successful candidate must possess strong analytical and computer skills with basic understanding of SPC.<br>**Technician position-**<br>Must have a minimum of two year technical degree, and three years of experience in vacuum, plasma processing, control electronics, machine design, or electrical circuitry. Must possess strong interpersonal and oral communication skills. Computer literacy is a plus.<br>2 |
| Quantum Logic Devices, Inc. | Our focus is on single-electron transistor platforms, based on quantum dots that use very low power. "We're using nanotechnology to bring together "wet" biology and "dry" semiconductor electronics to create radically new products to improve healthcare" (http://quantumlogicdevices.com/index.html) founded in 2000 to commercialize molecular-scale transistors for biological testing and electronics. The company's core technology encompasses single-electron devices that enable a simpler way to analyze DNA, protein, and molecular interactions. | ? |

[5] Source: The International Nanotechnology Business Directory, http://www.nanovip.com/taxonomy/term/184, Nanotechnology: Austin. Last Updated: January 17, 2007; Retrieved May 3, 2007.

| Company Name | Description | Employment |
|---|---|---|
| HelioVolt Corporation | HelioVolt has developed the fastest and most effective way to manufacture CIS (Copper Indium Selenide), the most reliable and best-performing thin film material for generating electricity from sunlight. | Take directly from their website: "For more information regarding careers in HelioVolt, please contact: Human Resources – Recruiter, email: recruiter@heliovolt.com"<br><br>DIRECTOR OF PRODUCT DEVELOPMENT<br>ELECTRICAL PRODUCT DESIGNER<br><br>ELECTRONIC EQUIPMENT SPECIALIST:<br>**Job description:**<br>The Electronic Equipment Specialist researches, designs, and tests mechanical, electrical, and electronic equipment used in the manufacturing process. Performs ongoing maintenance tasks, repairs, and upgrades on electrical equipment. Keeps records of equipment performance and problems. Suggests and implements programs for increasing the efficiency and reliability of equipment.<br>* Responsible for the day-to-day activities that support the hardware development and engineering department.<br>* Utilizes established product specifications, drawings, and prototypes to perform testing and troubleshooting tasks.<br>* Responsible for debugging, modifications and repairs. May perform research activities and collect data to assist with the development of prototypes and models.<br>* Performs moderately complex manufacturing tasks associated with thin film processing equipment<br>* Controls and manages Engineering Change Order Process<br>**Essential Skills and Education**<br>* Associate's degree or equivalent from a two-year College or technical school or 1-3 years of related experience and / or training<br><br>ELECTRONICS & INSTRUMENTATION ENGINEER<br>ENVIRONMENTAL RELIABILITY ENGINEER<br>INDUSTRIAL AUTOMATION ENGINEER<br>SR. EQUIPMENT DESIGN ENGINEER<br>SR. EQUIPMENT DESIGN ENGINEER<br>SR. THIN FILMS PROCESS ENGINEER (DIELECTRIC COATINGS)<br>9 |
| Introgen Therapeutics, Inc. | Introgen Therapeutics is a biopharmaceutical company focused on the discovery, development and commercialization of molecular therapies for the treatment of cancer and other serious diseases. The company uses nanoparticles to target cancer tumors. | ? |

| Company Name | Description | Employment |
| --- | --- | --- |
| Nanocoolers | At NanoCoolers we are developing advanced cooling solutions utilizing thin-film thermoelectrics. Our thermal management solutions have wide-ranging applications such as computing, communications, biomedical systems, climate control and refrigeration. | Take directly from their website: "If you did not find an opening for your specific skills, but you're successful in your field, and you want meaningful work that will use your talents right away, we would still like to hear from you. Email us at: careers@nanocoolers.com"<br><br>Administration (0, currently open)<br>Engineering (1)<br>Finance (0, currently open)<br>Marketing (0, currently open)<br><br>Operations (1)<br>*Process Technician for Thin-Film Engineering*<br>**Location:** Austin<br>**Education Requirements:** 2-year A.S. degree in Chemistry or Physics<br>**Job Experience:** Required Skills and Qualifications: Minimum of 5+ years in thin film materials and process development nanoCoolers is seeking a thin-film process technician to join our dynamic Austin, TX-based company and be a part of a small team of engineers developing the materials, deposition and processing technology for the company's thin-film thermoelectric cooler products. The candidate must have a track record of supporting thin-film material and process technology development, with hands-on experience in thin-film processing including sputter deposition, plasma-etching, cleaning, and analytical techniques for characterizing metals and dielectrics. Knowledge of photolithography, statistical process control or technology transfer to manufacturing would be a plus. The candidate also needs to be a self-starter requiring minimal supervision on a day-to-day basis, and the ability to work well in a team environment.<br>**Required Qualifications:** A minimum of 5 years experience in semi-conductor manufacturing operations or equivalent is required.<br>**Preferred Qualifications:** Prefer 10+ years experience in semi-conductor manufacturing operations and four year degree a plus.<br>Sales (0, currently)<br>2 |
| NovaCentrix, Corp.<br><br>(Formerly Nanotechnologies, Inc.) | Founded in 1999 and formerly known as Nanotechnologies, Inc., NovaCentrix is a materials and equipment manufacturer providing nano-enabled products, processes and solutions that encompass ink and photonic curing technology, nanoenergetic materials and anti-viral/microbial applications. | Take directly from their website: "Employment Opportunities: What inspires you? We have an outstanding team at NovaCentrix dedicated to continuing an environment of innovation. We are always interested in speaking with extraordinary individuals. Please feel free to send your resume, including your specific interests in NovaCentrix to: jobs@novacentrix.com," Retrieved from, **http://www.novacentrix.com/**, on May 3, 2007.<br>? |

| Company Name | Description | Employment |
|---|---|---|
| Teravicta Technologies, Inc. | Teravicta Technologies provides relay and RF switch components and module solutions based on proprietary MEMS technology. Applications for Teravicta's products include test instrumentation, cell phones, wireless LANs, fixed broadband wireless, cellular base stations, industrial control, satellites, military communications, and radar systems (Retrieved from, http://www.teravicta.com/faq.php | — **Positions currently available:**<br>• Sales Field Application Engineer<br>• RF Design Engineer<br>• Micro-fabrication Operators<br>Also, we are always interested in hearing from individuals with the following backgrounds and interests:<br>• Sales Professionals<br>• Mechanical Design Engineers<br>• Packaging Engineers and Technicians<br>3 |
| Xidex Corporation | Xidex Corporation is an Austin-based nanotechnology company in the business of developing carbon nanotube based mechanical, electrical and logic devices together with micro- and macro-scale products that incorporate these nanodevices. Xidex Corporation was founded in 1997 as an Austin-based Texas Corporation by Vladimir Mancevski, Chief Technology Officer and Dr. Paul F. McClure, President and CEO. Dr. McClure is a former professor of mechanical engineering at UT Austin. The company is wholly owned by its co-founders (Retrieved from, **http://www.xidex.com/**, on May 3, 2007). | ? |
| Nano Proprietary, Inc. (NNPP) | A holding company consisting of two high-tech subsidiaries: Applied Nanotech, Inc. **(ANI)**, and Electronic Billboard Technology, Inc. **(EBT)**. These two technical subsidiaries focus on specific technologies, playing an integral part of Nano-Proprietary's vision of providing cutting-edge solutions for the microelectronic and display industries. The Company's focus is Carbon Field Emission (CFE) products, and related electronic display products utilizing thin carbon film, diamond film, and diamond-like carbon film (DLC). ANI—"We have no manufacturing facilities and have no intention of establishing any such facilities. We intend to work with others that will manufacture products using our technology and license our technology to those manufacturers" (Retrieved from http://www.nano-proprietary.com/About/CompanyProfile.asp, on May 3, 2007). | ANI— **Positions currently available:**<br>**Technical Assistant**<br>We are seeking a technical assistant to begin by October 1. This new position involves the preparation and analytical testing of new microelectronic materials. The successful candidate will work with a team evaluating and improving these materials.<br>**Education**: Associate degree in related technical field or equivalent experience.<br>**Qualifications**<br>Familiarity with electronics test instrumentation is necessary. Candidate shall have good computer skills. Experience with Microsoft Office applications and competence with MS Word and MS Excel a must. Candidate must be able to carry out of data analysis procedures using statistical method. Previous experience with ink dispersions, printing method and sample preparation is desired. Familiarity with technical ink processes a plus. Microelectronics material characterization analysis experience is desirable.<br>**Primary Responsibilities**<br>Prepare ink formulations and perform ink characterization and testing.<br>Prepare samples for and perform microscopic and conductivity examination.<br>Prepare test procedures and set-up test equipment.<br>Document test results and prepare test reports.<br>1 |

| Company Name | Description | Employment |
|---|---|---|
| Molecular Imprints, Inc. (MII) | Molecular Imprints, Inc (MII), is providing enabling lithography systems and technology for manufacturing applications in the areas of: nano devices, micro structures, advanced packaging, bio devices, optical components and semiconductor devices.<br>founded in Austin, TX, in 2001 to design, develop, manufacture and support imprint lithography systems to be used by semiconductor device and other industry manufacturers. **Molecular Imprints is the largest single organization in the world working solely on imprint lithography.** | "In 2005, employed about 90 people." source: http://www.xidex.com/pubs/news0008.htm (Advanced Material Research Center, 2005).<br>**Positions currently available:**<br>**Marketing Manager / Director; Research Engineer; Production Control Lead; Lead Electronics Technician**<br>Position Summary for Lead Electronics Technician…<br>Lead Electronics Technician responsible for integration, testing, and troubleshooting of electronic chassis assemblies, printed circuit board assemblies, and cable assemblies. Additional responsibilities to include maintaining electronics laboratory and managing production schedules.<br>**Essential Functions**<br>1. Read/interpret electrical schematics, cable drawings, and engineering assembly drawings effectively<br>2. Wiring electrical devices to CE standards<br>3. Perform crimping utilizing AMP/Tyco, Molex, Hirose, and Daniels tools<br>4. Perform through hole, surface mount, and contact soldering (proficiency required)<br>5. Integrate cable harnesses (proficiency required)<br>6. Utilize digital multi-meter, oscilloscope, signal tracer to troubleshoot issues with electrical assemblies<br>7. Maintain electrical floor stock<br>8. Maintain electrical lab<br>9. Schedule electrical production to coincide with manufacturing schedules<br>10. Integrate R&D assemblies for test and development<br>11. Utilize computerized label makers (Globalmark)<br>12. Read/interpret Bills of Materials<br>13. Formulate and execute Engineering Change Orders/Requests (ECO/ECR)<br>14. Review, interpret, and work from Pro Engineer Mechanical drawings/designs<br>15. Utilize MAS 200 ERP system – basic to intermediate level<br>16. Utilize MS Outlook, Excel, and Word – basic to intermediate level<br>17. Working evening and weekend shifts as required<br>18. Must be self-motivated and able to work without supervision<br>**Qualifications**<br>Education: Two (2) year Technical School or equivalent military/work experience<br>Experience Minimum five years (5) years performing like work.<br>· IPC Standards Knowledge or certification preferred<br>Retrieved from http://www.molecularimprints.com/AboutMII/AboutMII.html, on May 3, 2007.<br>4 |

# APPENDIX D: LIST OF NANOSCHOLAR PLACEMENTS

NanoScholar Program-List of Associate Degree Student Placements
163 interns to date (target total 160)

| Degree Type | Major | College or University | NanoScholar Position at SEMATECH | Duration (wks) |
|---|---|---|---|---|
| 2-yr | Appl Sci / Network | Lee College | FEP Manufacturing Technician | 15 |
| 2-yr | Automation | ACC | Facilities Services Intern | 15 |
| 2-yr | Automation | TSTC Harlingen | Interconnect Maintenance Technician | 15 |
| 2-yr | Biology | ACC | Process Characterization Technician | 26 |
| 2-yr | Biotechnology | ACC | Litho Maintenance Technician | 15 |
| 2-yr | Biotechnology | ACC | Process Characterization Technician | 15 |
| 2-yr | Chemistry | ACC | Litho Manufacturing Technician | 15 |
| 2-yr | Computer Science | ACC | FEP Manufacturing Technician | 15 |
| 2-yr | Computer Science | ACC | Industrial Engineer Intern | 15 |
| 2-yr | EE | ACC | Facilities Operations Technician | 26 |
| 2-yr | Electronics | ACC | E-Test Technician | 15 |
| 2-yr | Electronics | ACC | FEP Maintenance Tech | 15 |
| 2-yr | Electronics | ACC | Litho Maintenance Tech | 15 |
| 2-yr | Electronics | ACC | IC Maintenance | 15 |
| 2-yr | Electronics | ACC | Facilities Services | 15 |
| 2-yr | Electronics | ACC | Facilities Services | 15 |
| 2-yr | Electronics | ACC | FEP Maintenance Tech | 15 |
| 2-yr | Electronics | ACC | FEP Maintenance Tech | 15 |
| 2-yr | Electronics | ACC | Litho Maintenance Tech | 15 |
| 2-yr | Electronics | ACC | Metrology Manufacturing Technician | 26 |
| 2-yr | Electronics | ACC | Interconnect Maintenance Technician | 26 |
| 2-yr | Electronics | ACC | Interconnect Manufacturing Technician | 26 |
| 2-yr | Electronics | ACC | FEP Maintenance Technician | 26 |
| 2-yr | Electronics | ACC | Facilities Services | 15 |
| 2-yr | Electronics | ACC | Litho Maintenance Technician | 15 |
| 2-yr | Electronics | ACC | Litho Maintenance Technician | 15 |
| 2-yr | Electronics | ACC | E-Test Engineering | 15 |
| 2-yr | Electronics | ACC | Interconnect Maintenance Technician | 15 |
| 2-yr | Electronics | ACC | FEP Maintenance Technician | 15 |
| 2-yr | Electronics | ACC | Metrology Manufacturing Technician | 15 |
| 2-yr | Electronics | ACC | Metrology Manufacturing Technician | 15 |
| 2-yr | Electronics | ACC | FEP Manufacturing Technician | 15 |
| 2-yr | Electronics | ACC | Metrology Manufacturing Technician | 15 |
| 2-yr | Electronics | ACC | Litho Maintenance Technician | 15 |
| 2-yr | Electronics | ACC | Facilities Services | 15 |
| 2-yr | Electronics | ACC | FEP Maintenance Technician | 26 |
| 2-yr | Electronics | TSTC | Harlingen Metrology Maintenance Tech | 15 |
| 2-yr | Industrial Mgmt | ACC | Metrology Manufacturing Technician | 15 |
| 2-yr | ME | ACC | Interconnect Maintenance Technician | 26 |
| 2-yr | Physics | ACC | FEP Manufacturing Tech | 15 |
| 2-yr | Physics | ACC | Interconnect Manufacturing Technician | 15 |
| 2-yr | Pre-Eng | ACC | Facilities Operations Tech | 15 |
| 2-yr | Pre-Eng | ACC | Metrology Manufacturing Tech | 15 |
| 2-yr | Pre-Eng | ACC | FEP Maintenance Technician | 15 |
| 2-yr | Pre-Eng | ACC | E-Test Technician | 15 |
| 2-yr | Pre-Eng | ACC | Metrology Manufacturing Technician | 15 |
| 2-yr | Pre-Eng | ACC | Facilities Services | 15 |
| 2-yr | Pre-Eng | ACC | E-Test Technician | 15 |
| 2-yr | Pre-Engineering | ACC | FEP Maintenance Technician | 26 |
| 2-yr | Robotics | ACC | Metrology Manufacturing Technician | 15 |
| 2-yr | Robotics | ACC | Facilities Engineering | 15 |
| 2-yr | Robotics | TSTC | Harlingen Litho Maintenance Technician | 15 |
| 2-yr | Semiconductor | ACC | Facilities Services | 15 |
| 2-yr | SMT | ACC | Litho Maintenance Technician | 26 |
| 2-yr | SMT | ACC | E-Test Technician | 26 |
| 2-yr | SMT | ACC | Interconnect Maintenance Technician | 15 |

NanoScholar Program-List of Bachelor's Student Placements
163 interns to date (target total 160)

| Degree Typ | Major | College or University | NanoScholar Position at SEMATECH | Duration (wks) |
|---|---|---|---|---|
| 4-yr | Bioengineering | UT at Austin | Litho/Metrology Engineering | 26 |
| 4-yr | Bioengineering | UT at Austin | FEP Manufacturing Technician | 26 |
| 4-yr | Bioengineering | UT at Austin | Metrology Engineering | 26 |
| 4-yr | Bioengineering | UT at Austin | Process Characterization Technician | 26 |
| 4-yr | Bioengineering | UT at Austin | Litho Manufacturing Technician | 26 |
| 4-yr | Bioengineering | UT at Austin | Manufacturability System Analyst | 26 |
| 4-yr | Bioengineering | UT at Austin | Interconnect Engineering | 26 |
| 4-yr | Bioengineering | UT at Austin | Simulation Analyst | 26 |
| 4-yr | Bioengineering | UT at Austin | Quality Engineer | 15 |
| 4-yr | Bioengineering | UT at Austin | Process Characterization Technician | 15 |
| 4-yr | Bioengineering | UT at Austin | FEP Division Intern I | 15 |
| 4-yr | Bioengineering | UT at Austin | Litho Manufacturing Technician | 15 |
| 4-yr | Bioengineering | UT at Austin | Litho Engineering | 15 |
| 4-yr | Bioengineering | UT at Austin | ESH Engineer | 15 |
| 4-yr | Bioengineering | UT at Austin | FEP Manufacturing Technician | 15 |
| 4-yr | Bioengineering | UT at Austin | Metrology Engineering | 15 |
| 4-yr | Bioengineering | UT at Austin | Process Characterization Technician | 15 |
| 4-yr | Bioengineering | UT at Austin | FEP Division Intern I | 15 |
| 4-yr | Bioengineering | UT at Austin | Quality Engineer | 15 |
| 4-yr | Bioengineering | UT at Austin | Process Characterization Technician | 26 |
| 4-yr | Biology | Huston-Tillotson | Process Characterization Technician | 15 |
| 4-yr | Biotechnology | St. Edward's Univ | Process Characterization Tech (TEM Prep) | 26 |
| 4-yr | Biotechnology | UT at Austin | Litho Engineering | 26 |
| 4-yr | Biotechnology | UT at Austin | Litho Engineering Intern | 26 |
| 4-yr | Biotechnology | UT at Austin | Interconnect Engineering Intern | 26 |
| 4-yr | Chemical Eng | ACC | Process Characterization Technician | 15 |
| 4-yr | Chemical Eng | UT at Austin | FEP Engineering Intern | 26 |
| 4-yr | Chemical Eng | UT at Austin | Process Characterization Technician | 15 |
| 4-yr | Chemistry | UT at Austin | Process Characterization Technician | 15 |
| 4-yr | Computer | Eng UT at Austin | FEP Division Intern I | 26 |
| 4-yr | Computer | Eng UT at El Paso | Product Engineer | 15 |
| 4-yr | Computer Sci | St. Edward's Univ | Manufacturability System Analyst | 26 |
| 4-yr | EE | Univ of Houston | E-Test Technician | 26 |
| 4-yr | EE | UT at Austin | FEP Division Intern I | 26 |
| 4-yr | EE | UT at Austin | FEP Manufacturing Technician | 15 |
| 4-yr | EE | UT at Austin | Litho Manufacturing Technician | 15 |
| 4-yr | EE | UT at Austin | Facilities Engineering | 15 |
| 4-yr | EE | UT at Austin | Litho Maintenance Technician | 15 |
| 4-yr | EE | UT at Austin | Lithography Division Intern III | 15 |
| 4-yr | EE | UT at Austin | E-Test Engineering | 15 |
| 4-yr | EE | UT at Austin | Interconnect Division Intern I | 26 |
| 4-yr | EE | UT at El Paso | FEP Division Intern I | 15 |
| 4-yr | EE | UT at El Paso | Interconnect Manufacturing Technician | 15 |
| 4-yr | EE | UT at El Paso | FEP Engineering | 15 |
| 4-yr | EE | UT at El Paso | Interconnect Manufacturing Technician | 15 |
| 4-yr | EE | UT at El Paso | Interconnect Manufacturing Technician | 15 |
| 4-yr | EE | UT San Antonio | Metrology Engineering | 26 |
| 4-yr | Engineering | UT at Austin | Facilities Services | 26 |
| 4-yr | Engineering | UT at Austin | Simulation Analyst - ISMI | 26 |
| 4-yr | Materials Science | UT at El Paso | Metrology Engineering | 15 |
| 4-yr | ME | Texas State | Interconnect Engineering Intern | 26 |
| 4-yr | ME | Texas State | Reticle Design Engineer | 26 |
| 4-yr | ME | Texas State | Litho Engineering | 26 |
| 4-yr | ME | Texas State | Facilities Engineering | 15 |
| 4-yr | ME | Texas State | Facilities Engineering Intern | 26 |
| 4-yr | ME | Texas State | Facilities Operations Technician | 26 |
| 4-yr | ME | UT at Austin | FEP Engineering | 26 |
| 4-yr | ME | UT at Austin | Metrology Engineering | 26 |
| 4-yr | ME | UT at Austin | Facilities Engineering | 15 |
| 4-yr | ME | UT at Austin | FEP Manufacturing Technician | 15 |

NanoScholar Program-List of Bachelor's Student Placements
163 interns to date (target total 160)

| **Degree Typ** | **Major** | **College or University** | **NanoScholar Position at SEMATECH** | **Duration (wks)** |
|---|---|---|---|---|
| 4-yr | ME | UT at Austin | Facilities Engineering | 26 |
| 4-yr | ME | UT Pan-Am | Facilities Services | 15 |
| 4-yr | ME | UT Pan-Am | Facilities Engineering | 15 |
| 4-yr | ME | UT Pan-Am | Metrology Engineering | 15 |
| 4-yr | ME | UT Pan-Am | FEP Engineering | 15 |
| 4-yr | Nanotechnology | Texas State | Simulation Analyst | 26 |
| 4-yr | Physics | Texas State | Interconnect Engineering | 26 |
| 4-yr | Physics | Texas State | Process Characterization Technician | 26 |
| 4-yr | Physics | UT at Austin | FEP Division | 26 |
| 4-yr | Physics | UT at Austin | Industrial Engineering | 26 |
| 4-yr | Physics | UT at Austin | Process Integration Engineering Intern | 26 |
| 4-yr | Physics | UT at Austin | Metrology Engineering | 26 |
| 4-yr | Pre-Eng | Texas State | FEP Engineering | 26 |
| Grad | Chemical Eng | UT at Austin | Process Integration Engineering | 52 |
| Grad | Chemistry | Texas State | Interconnect Division Intern | 52 |
| Grad | Computer Eng | UT at El Paso IT | (Process Characterization and Mfg Apps) | 15 |
| Grad | EE | UT at Austin | Process Integration Engineering | 52 |
| Grad | EE | UT at Austin | FEP Division | 52 |
| Grad | EE | UT at Austin | FEP Division | 52 |
| Grad | EE | UT at Austin | FEP Division Intern II | 15 |
| Grad | EE | UT at Austin | FEP Division Intern II | 15 |
| Grad | EE | UT at Austin | FEP Division Intern II | 15 |
| Grad | EE | UT at Austin | FEP Division Intern II | 15 |
| Grad | EE | UT at Austin | FEP Division Intern I | 52 |
| Grad | EE | UT at Austin | FEP Engineering | 52 |
| Grad | EE | UT at Dallas | FEP Division Intern I | 15 |
| Grad | EE | UT at Dallas | FEP Division Intern | 52 |
| Grad | EE | UT at El Paso | Defect Metrology Intern | 26 |
| Grad | EE | UT at El Paso | Defect Metrology Intern | 15 |
| Grad | Materials Sci & Eng | UNT | FEP Division | 52 |
| Grad | Materials Science | UNT | FEP Division | 52 |
| Grad | Materials Science | UT at Austin | Front End Processing Division Intern | 52 |
| Grad | Materials Science | UT at El Paso | Lithography Metrology Intern | 26 |
| Grad | ME | UT at Austin | Interconnect Engineering | 52 |
| Grad | Physics | Texas State | Process Integration Engineer | 52 |
| Grad | Physics | Texas State | Quality Engineer | 52 |
| Grad | Physics | Texas State | FEP Division Intern I | 52 |
| Grad | Physics | Texas State | FEP Division Intern II | 26 |
| Grad | Physics | Texas State | FEP Division Intern II | 26 |
| Grad | Physics | UNT | FEP Engineering | 26 |
| Grad | Physics | UT at Austin | Lithography Metrology Intern | 15 |
| Grad | Physics | UT at Austin | Process Characterization Analyst | 52 |
| Grad | Physics | UT at Austin | Interconnect Engineering | 52 |
| Grad | Physics | UT at Austin | FEP Division Intern I | 52 |
| Grad | Physics | UT at Austin | Defect Metrology Intern | 26 |
| Grad | Physics | UT San Antonio | Metrology Manufacturing Technician | 15 |
| Grad | Pre-Eng | UT at Austin | Simulation Analyst | 52 |

## APPENDIX E: MECHATRONICS SURVEY FORM

**Mechatronics Multi-skill Requirements for Technicians at Your Company**

**Your Industry________________Number of technicians at your company_____**

Please designate which skill groupings or individual skills sets are: relevant for your technicians, high priority for your company, challenging to find/prepare workers. Please check only boxes that apply. Checking the grey categories implies that you need all or most of the individual skill sets described below in that category heading.

| Skill/Knowledge Topic | Relevant for our technicians | High Priority for our company | Challenging to find/ prepare workers with these skill sets |
|---|---|---|---|
| **Basic Skills** | | | |
| Foundational Mathematics | | | |
| Foundational Science | | | |
| Introduction to Computers | | | |
| **Practical Hand Work Skills** | | | |
| Use of hand tools | | | |
| Soldering techniques | | | |
| General repair skills (e.g., building connections for cables, use of tap & die sets for removing bolts, remove & replace pipes, etc) | | | |
| **Schematics understanding and usage** | | | |
| Board-level schematic interpretation and usage to troubleshoot at board level (e.g., **fix a board**) **OR** | | | |
| System/subsystem schematic interpretation and usage to troubleshoot at system level (e.g., find what is malfunctioning in system & **replace board**) | | | |
| **Computer Software & Systems** | | | |
| Computer Programming (C, C++, etc.) | | | |
| Internetworking | | | |
| Computer-Aided Design (CAD) | | | |
| DeviceNet Industrial Control software or related | | | |
| Allen Bradley PLC software or related | | | |
| LabView, NI data acquisition software or related | | | |
| **Hydraulics/ Pneumatics** | | | |
| Fluid Power | | | |
| Electro-Fluid Power | | | |
| **Electricity & Electrical Systems (AC/DC)** | | | |
| Electrical Wiring & Installation | | | |
| Electrical Instruments & Measurements | | | |
| Power Distribution | | | |
| Power devices such as contactors, motor starters, relays, circuit breakers, disconnects, etc. | | | |
| **Electronics** | | | |
| DC and AC circuits (resistors, inductors, capacitors) | | | |
| Digital circuits | | | |
| Semiconductor Electronics | | | |
| Operational amplifiers | | | |

| Skill/Knowledge Topic | Relevant for our technicians | High Priority for our company | Challenging to find/ prepare workers with these skill sets |
|---|---|---|---|
| Microprocessor hardware & software programming | | | |
| **Electric Motors (AC, DC, Stepper, Servo)** | | | |
| **Electrical Motor Control** | | | |
| Mechanical Drives | | | |
| Electronic Drives | | | |
| Servo Control | | | |
| **Programmable Logic Controllers** | | | |
| Centralized | | | |
| Decentralized | | | |
| **Sensors** | | | |
| Photo sensors | | | |
| Limit Switches | | | |
| Inductive | | | |
| Capacitative | | | |
| Pressure | | | |
| Temperature | | | |
| Flow | | | |
| **Robotics** | | | |
| Automated Manufacturing | | | |
| Computer Integrated Manufacturing (CIM) | | | |
| Instrumentation (advanced) | | | |
| Specialized Robotic control software | | | |
| Robotic motors/drives/ hardware configuration | | | |
| Robotic software development/programming | | | |
| **Machining/Fabrication** | | | |
| Conventional Machining/Fabrication | | | |
| CNC Operations | | | |
| CNC Machine Maintenance | | | |
| CNC Machine Programming | | | |
| CNC Trouble Shooting | | | |
| **Maintenance Practices** | | | |
| Preventative Maintenance | | | |
| Lubrication | | | |
| **Other categories** | | | |
| Quality/SPC Training | | | |
| Industrial Safety Training | | | |
| Vacuum Concepts | | | |
| RF Concepts | | | |
| Renewable Energy Concepts | | | |
| Other (please specify) | | | |

**COMMENTS**