# AC 1999-292: Microelectronics Teaching Factory At Arizona State University Eastmesa, Arizona, USA

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# Microelectronics Teaching Factory at Arizona State University East Mesa, Arizona, USA

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**ABSTRACT**

The Microelectronics Teaching Factory is an Intel, Motorola and ASU East partnership to equip and staff a top-of-the-line teaching facility that mirrors a real microchip fabrication factory. This facility will provide a unique learning environment for students from ASU East, ASU Main and Maricopa Community Colleges who represent the future microelectronics workforce. As well, Intel, Motorola and other local industrial and educational partners will use the facility for education and training purposes.

## Introduction:

The catalyst for a ***teaching factory*** at Arizona State University (ASU) East is the worldwide shortage of trained personnel in the semiconductor manufacturing industry in the 1990s [1]. Semiconductor manufacturing constitutes one of the fastest growing industries in the world [2]. In spite of cyclical industry downturns, the projected long-term need for highly skilled persons for this industry is still substantial. The Semiconductor Industry Association (SIA) has predicted that 50 to 100 wafers fabrication plants will be built and staffed by companies worldwide, during the period from 1994 to 2000. These new facilities will have generated over 120,000 new workforce positions. Furthermore, due to rapidly increasing technological complexity the SIA projections through the year 2010 indicate that every three years the overall technological change will be multiplied by a factor of four. Preparation of the workforce must meet the labor demands of both today and the future. Hence, to provide for the preparatory needs the university, postsecondary, and secondary education system must establish and sustain programs to meet these semiconductor workforce needs. To assure the existence of the needed workforce, semiconductor manufacturers nationally and in Arizona have launched ad campaigns to attract persons into preparation for the future semiconductor workforce. Many manufacturers have begun to enter into partnerships with universities, community colleges and secondary institutions to prepare their graduates for positions in the semiconductor fabrication workforce.

The College of Technology and Applied Sciences (CTAS) at Arizona State University East is appropriately positioned to respond to the skilled workforce need faced by the local semiconductor industry. The ASU East Microelectronics Teaching Factory involves a partnership between Arizona State University, Intel, Motorola, local industry and local and state governments. The Teaching factory design philosophy encompasses the flexibility to accommodate future technology changes and high standards of the university, city and county,

and partnering corporations with regard to health, safety, environmental responsibility and manufacturing quality.

Semiconductor manufacturing survives by rapid change to develop, produce and market new products better, faster and cheaper than the competition. Factories responded to this challenge by expecting employees to integrate other jobs into their own and work with less management support. The most flexible fab employees run production, make process-engineering decisions, manage workflow, maintain the equipment, and train as a team. These flexible skill requirements presuppose a broad knowledge in science, math and communications. Few employees are that versatile. Some have a narrowly focused two-year education, while many others have no formal education beyond high school. As factories grow in size and complexity the number of graduates are ready for these jobs is not adequate. A key component of job readiness is work-based experience. Contextual learning opportunities are fundamentally limited in the semiconductor industry due to restrictions imposed by production constraints, scheduling and legal (liability) issues. One of the goals of the ASU East teaching factory is to bridge this gap through contextual learning in a live teaching factory.

**ASU East Teaching Factory:**

***Cleanroom design***

The Arizona State University Board of Regents authorized microelectronics teaching factory plan to construct on the ASU East campus in Mesa, Arizona and the state legislature appropriated ***six million dollars*** to build the facility. ASU East is located at the former Williams Air Force Base and commissary building was selected as the site for the teaching factory. The warehouse area of the building was selected as the location of the teaching Factory due to the high ceiling and close proximity to the shipping/receiving dock. The design and construction of the building was accomplished in two phases. The first phase consisted of the design and construction of the classrooms, offices, and laboratories, upgrade of the HVAC system by adding chillers, cooling towers, and boilers. The design and construction of the Teaching Factory became the second phase of the project. Approximately 15,000 square feet floor space, which is around 15-25 percent of the building, is dedicated to the Teaching Factory. The industry partners Motorola and Intel have provided the ongoing support to this project from the conceptual stage.

The design phase of the Teaching Factory was challenging due to its unique requirements and limitations including high user diversity, sporadic equipment utilization, low capital budget, and comprehensive equipment set (i.e. wafer fab, test, assembly, factory support etc.). An equally challenging problem was to design a cost-effective facility that is fully compliant with building, safety, health, and environmental codes, standards, and regulations.

The cleanroom design of the Teaching Factory was performed using several resources including textbooks, technical publications, professional society publications, and the Internet. The cleanroom design textbooks [3-5] provided fundamentals regarding the history of cleanrooms, airflow and filtration design, general design guidelines, and contamination transport and deposition. The primary design feature of a cleanroom is associated with the reduction of

airborne contaminants by means of airflow and filtration [3-5]. Collective definition of a cleanroom as cited in these references is ***a cleanroom as a room in which the concentration of airborne particulate is controlled.*** Air filtration in the cleanroom is practiced to remove particulates generated within the clean area and from outside sources. High efficiency particulate air (HEPA) filters are used to remove the particulate from recirculated and incoming air streams. HEPAs have particle capture efficiencies of 99.97% for particles greater than 0.3 micron. Several technical publications were consulted to look into the latest industry trends.

### *Manufacturing Process*

The primary semiconductor manufacturing process targeted for this facility is complementary metal oxide semiconductor (CMOS) wafer fabrication process. Numerous references [6-9] cited the advantages of CMOS over other semiconductor technologies. Primary advantages include low power dissipation, low cost, high packing density, and high-speed characteristics. A schematic flow of for IC fabrication from design to final unit is shown below in figure 1.

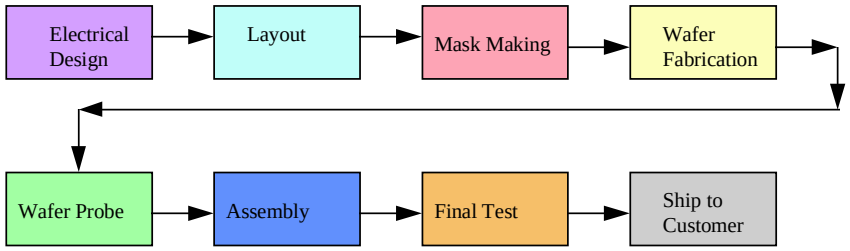


***Figure 1. Basic Processing Sequence of IC Manufacturing***

Intel, one of the industry partners has committed to donate the equipment needed to execute the CMOS device fabrication in the Teaching factory. The other industry partner, Motorola has committed to provide technical expertise for three years to make this factory operational. Other local industry partners are also assisting us with assembly and test equipment to facilitate the backend process. The expected completion of the project is summer 1999.

### *Functions of Teaching Factory*

Primary function of the teaching factory is to create an infrastructure that can shadow the real industry experience with flexible constraints to prepare future workforce for careers in semiconductor manufacturing and supporting industries. This goal will be achieved through the integration of academic and work-based education by providing first hand exposure to a real-work environment (learning in context). The strong partnership nested around various industrial partners, State Government, and other educational entities is a very strong asset to this project.

### Peer Institutions with similar facilities

The universities listed as having microelectronics fabrication facilities included are MIT, University of North Texas, University of Michigan, Auburn University, ASU, Rochester Institute

of Technology (RIT), Penn State, University of Wisconsin, University of Texas-Austin, Northeastern University, University of Minnesota, Cornell, Stanford University, Washington, University of California-Davis, University of Toronto, University of Montreal, North Carolina State University, New Jersey Institute of Technology, University of Louisville, University of Notre Dame and Purdue University. The effective research tool that is used to obtain the information regarding peer institutions was the Internet web site, Semiconductor Subway Web site. The Massachusetts Institute of Technology Microsystems Technology Laboratory maintains the Web site and the site address is http://www.mtl.mit.edu/semisubway.html [10].

## Conclusions

ASU East is ***A new campus for a new Century.*** Open for business on August 26,1996 as a campus designed to be student-centered and seeking interaction with the community. ASU East is destined to help the State of Arizona and the United States develop and sustain a technologically able workforce by facilitating contextual learning environment. The teaching factory infrastructure that is presented in this paper will be used as vehicle to accomplish this goal

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*Dr. Albert L. McHenry is Professor and Dean of the College Technology and Applied Sciences at Arizona State University East, Mesa, Arizona. He holds a BS Industrial Technology form Southern University of Baton Rouge, Louisiana, a MS Technology and Ph.D. Technical Education from Arizona State. His area of technical specialization is digital electronics. He has industrial experience with the Boeing Co., 3M Co., Motorola Inc. and Minority Engineers of Louisiana. His current research interests include noise in digital systems design methodology and effective paradigms in engineering technology education. He is Co-director of The Western Alliance to Expand Student Opportunity, a National Science Foundation Alliance for Minority Participation project. Dr. McHenry has been actively involved in four-year technology programs for over 33 years. He was the 1996 winner of ASEE's Fredrick J. Berger Award.*

## SCOTT S. CARTIER

*Scott Cartier has been working for Motorola for the last ten years in positions including wafer fabrication facilities engineering, wafer fabrication process engineering, semiconductor assembly equipment engineering, and military electronics packaging. Scott presently leads the engineering team for the facilities fit-up of the MOS12 wafer fab factory expansion in Chandler, Arizona. Scott has a Masters Degree in Technology specializing in Microelectronics from Arizona State University and a Bachelors of Science degree in Mechanical Engineering from Ohio State University.*