Up Close: Center for Advanced Materials Processing at Clarkson University

Sonia K. Ellis and Edward P. McNamara Jr.

This article is part of a series focusing on the research capabilities and goals of interdisciplinary laboratories pursuing materials research in universities, industry, and government.

The Center for Advanced Materials Processing (CAMP) was established in 1985 by Clarkson University in Potsdam, New York. At that time, nearly half of the research at Clarkson was materials-related but was conducted in seven separate departments of science and engineering. To coordinate and encourage this strong materials program, CAMP was created as an interdisciplinary center dedicated to research on high-technology materials processing.

The current corporate sponsors of CAMP are Corning Incorporated, Eastman Kodak, Xerox Corporation, and IBM. These and over 30 other industrial members support individual research projects. In 1987 the New York State Science and Technology Foundation designated CAMP as the New York State Center for Advanced Materials Processing, entitling CAMP to $1 million per year in operating funds. In addition, CAMP is supported by federal and University sources.

In its role as an education and research initiative, CAMP has three goals:

1. Enhance Clarkson University's expertise and reputation as a center of excellence in materials processing research.
2. Greatly increase the mutually beneficial relationships between industrial organizations and the University; and
3. Strengthen graduate and undergraduate education in materials processing.

Research at CAMP

Innovative research by Egon Matijević, Distinguished University Professor, has contributed greatly to the development of the fundamental principles for the formation and interactions of colloidal dispersions. Using Matijević's work as a foundation, CAMP has developed four programs in high-technology materials research: electronic materials processing, fine-particle processing, particulate control in process equipment, and polymer processing.

Electronic Materials Processing (S.V. Babu, Director of Research)

The electronic materials processing group is exploring thin film deposition and etching, bulk crystal growth, and device characterization. Researchers are investigating new materials and processes that will enhance the performance of very large scale integration devices and packages; new device structures also are being developed. Each of the research projects listed below deals with the characterization or processing of materials that are integral to an electronic device or package.

■ Deposition of Electronic Materials. Excimer and CO_2 laser excitation and rf plasma-induced reduction are being used to deposit submicrometer metal and refractory powders. For example, AlN powders have been produced in a plasma reactor, and extremely pure copper and lead powders have been deposited by excimer laser reduction. The deposition and growth of thin films of metals, semiconductors, and III-V and II-VI materials also are being studied. High-purity AlN films and diamondlike carbon (DLC) films have been deposited and characterized. In addition, single crystal SiC films have been grown on Si substrates, and various electronic components have been encapsulated with

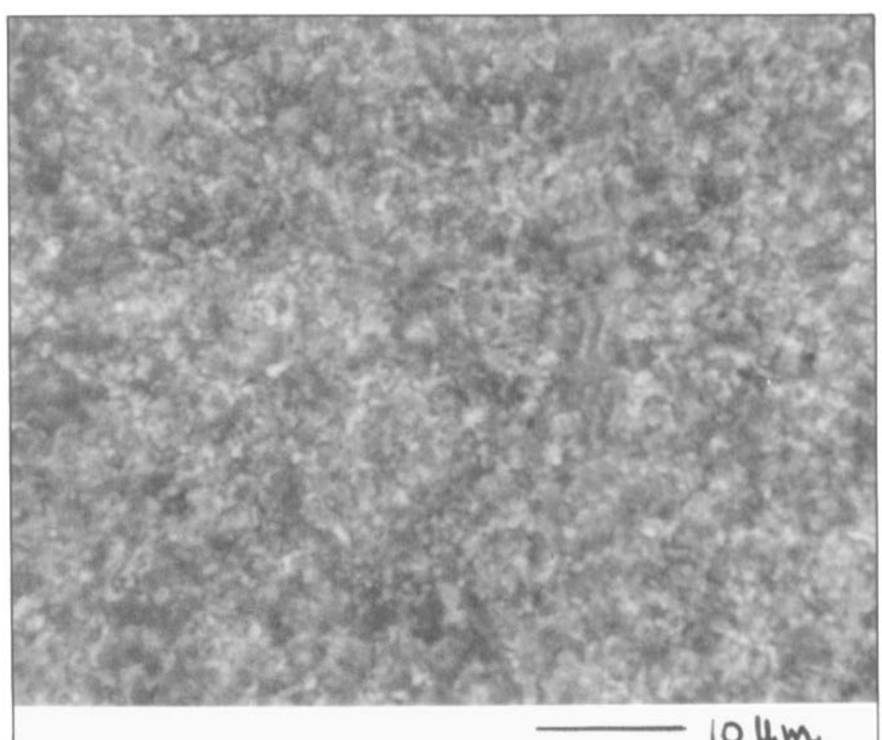

Figure 1. Copper film deposited by hydrogen plasma-induced reduction (magnification 1500x).

DLC films. In another project, researchers are investigating plasma desmearing as well as the electrodeposition and electroless deposition of metals in through-holes in electronic packages.

■ Bulk Crystal Growth. The role of transport processes during crystal growth is being evaluated. Specifically, defect formation and the effect of process parameters during the preparation of cadmium telluride and indium gallium antimonide are being determined.

■ Simulation. CAMP researchers are performing the three-dimensional simulation of submicrometer lithography and pattern transfer. Other productive areas of research have been the modeling of crystal growth, thin film deposition, polymer rheology, and modulation doped field effect transistor (MODFET) devices including coherent and incoherent current components. Predictive models have been developed for the current-voltage characterization of resonant tunneling devices and MODFET devices.

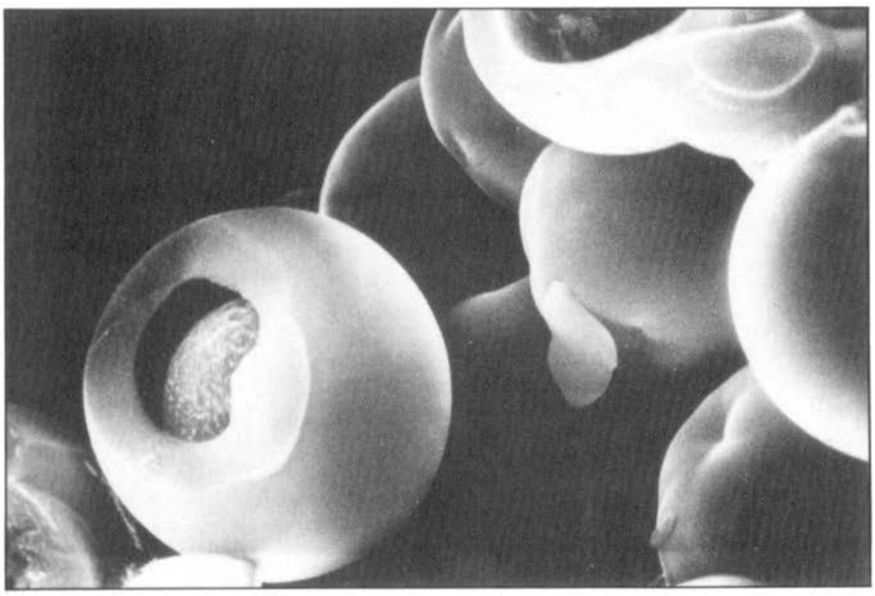

Figure 2. Mixed silica/titania particles generated by aerosol techniques (4mm = 1μm).

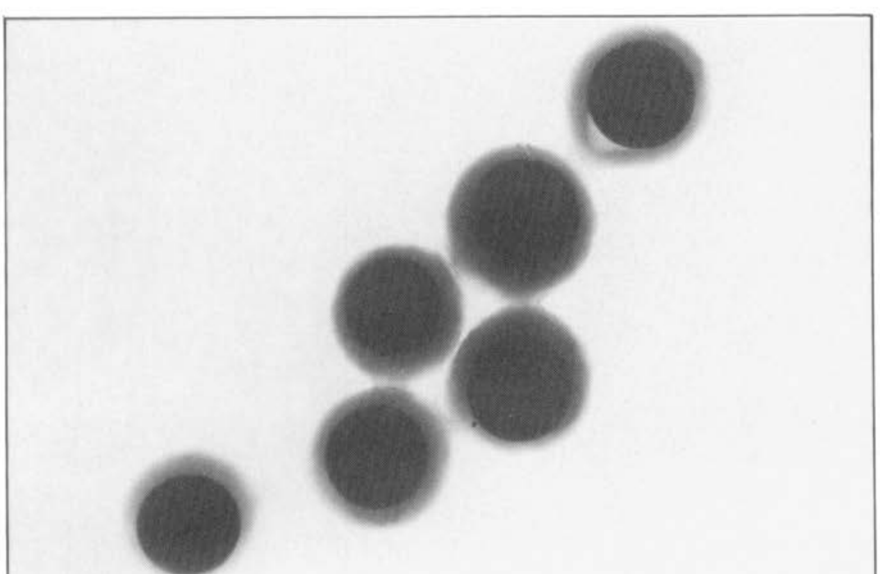

Figure 3. Polyurea coating on titania core particles prepared by aerosol techniques (12 mm = 0.5μm).

Fine-Particle Processing (Director of Research, Search in Progress)

Researchers in this group are investigating fine-particle preparation, processing, properties, and applications. One of the program's objectives is to develop improved techniques for producing particles of uniform size and shape. Another objective is to advance the technology for processing 0.1 to 100 micrometer-sized particles into useful products.

■ Fine-Particle Preparation. Many techniques are being applied to the preparation of fine particles. For example, titania and polyurea particles are being produced by aerosol generation devices. In another study, combustion techniques were used to generate titania and alumina particles. Also being developed are methods to prepare and store monodispersed fine particles of lead perovskites.

Ceramic powders of mixed metal oxides will be produced using a new microemulsion/gel method. Researchers also are studying the solidification of monodispersed metal powders. Cobalt, nickel, and cobalt-nickel alloys with narrow size distributions have been obtained.

Scale-up of precipitation processes is another important area. The technological requirements for scale-up of precipitation processes to make uniform metal oxide particles are being determined. This information will be used to design an economical system to meet industrial needs.

■ Fine-Particle Processing. One project in this area focuses on improving the control of the formation and properties of microcellular polymer foams containing particles. Other researchers are studying the influence of ultrasonic vibrations on the flow characteristics of thick slurries; the results of this work will be valuable to ceramic processing in improving extrusion and molding productivity. Also, the stability of mixed colloidal dispersions that contain heavy and buoyant particles is being evaluated.

■ Fine-Particle Properties and Applications. An ultrahigh vacuum analytical system has been designed to measure the structure and composition of material surfaces. A custom-built sample pretreatment cell, located outside the vacuum chamber, allows samples to be loaded rapidly without exposure to ambient conditions.

CAMP researchers also are exploring the interactions in multiple colloidal systems, such as heterocoagulation, dispersion, and detachment of particles from surfaces.

Particulate Control in Process Equipment (A. Busnaina, Director of Research)

The goal of the particulate control group is to develop techniques for submicron particulate removal, control, avoidance, identification, and characterization of surfaces and in process equipment. Researchers are aiming to eliminate particulate contamination problems in the manufacture of products such as integrated circuits, hard disks, photographic films, and pharmaceuticals.

Current research spans:

- Removal of Contaminants. Studies in this area are centered on the fluid dynamics of contaminant removal from surfaces. More effective apparatus for particle removal from both hydrophobic and hydrophilic silicon wafers have been developed. Researchers also are measuring the attachment and removal forces between particles and surfaces; results will be used to evaluate the effectiveness of various particle-removal techniques (including the use of drag forces, centrifugal forces, and ultrasonic cleaning).
- Control and Avoidance of Contaminants. Particles found in clean rooms and process equipment are generated by both people and equipment and then transported by air flow to critical surfaces. To reduce particle transport from contaminant sources, CAMP researchers have developed a computer program that predicts the air flow in various clean room and process equipment configurations.

Manufacturers of integrated circuits need high-purity process gases; however, contaminant particles may be generated in supply lines and filters. Researchers in this group have investigated the dependence of particle generation on surface material, vibration, wear, gas flow rate, and molecular impurities.

- Identification and Characterization of Contaminants. Light scattering is being used to locate and size particles on surfaces, in clean room air, and in process fluids. In another project, a scanning electron microscope has been constructed to operate at sub-keV energies, so that thinner films and smaller particles can be studied. New equipment also is being developed. For example, a single instrument has been built to combine three analytical techniques (ESCA, Auger spectroscopy, and low-energy electron diffraction); this system reduces the risk of contamination that occurs during sample transfer between instruments.

Polymer Processing (G. Campbell, Director of Research)

Researchers in this area of CAMP are investigating the relationship between polymer properties and processing conditions. The group's goal is to improve the understanding of these process-property interactions during the conversion of materials to useful articles, such as aircraft components, automotive parts, and food packages. The results will enable industry to produce polymers more efficiently, economically, and reliably.

Research projects in polymer processing focus on:

- Film Extrusion. Film extrusion represents the largest volumetric conversion of plastic materials into functional useful parts. A method to measure film internal temperatures has been found. A scale-up based on these procedures will be developed.
- Injection Molding. Injection molding is another major volumetric consumer industry. Researchers are investigating the effect of particle size and modulus on the properties of injection-molded parts with up to 30 vol.% filler. New control parameters that will improve the statistical process control reliability also are being developed.
- Composites. Research on colloidal composites is progressing in two areas, both directed toward the automotive and aerospace industries. The first area focuses on carbon-fiber directional composites. The goal of this research is to determine how process parameters (including temperature, pressure, and cooling rate) affect the adhesion of the fibers to thermoplastic and thermoset polymers. The second area concentrates on particulate composites. Researchers are studying the flow properties and the stress transfer mechanisms of these composite materials. Adhesives and adhesion also are being evaluated.
- Surface-Dominated Materials. Research projects on materials with high surface-to-volume ratios include investigations of the nucleation of foam, the flow and leveling of photoresists for microlithography, and the dielectric properties of multiphase materials.
- Structured Polymers. Novel methods based on liquid crystals are being used to make structured polymers. This new approach to polymerization is expected to yield materials with different characteristics. Physical and molecular properties will be evaluated to determine the utility of these polymers.

Looking Ahead

CAMP Director William R. Wilcox has announced the construction of a new CAMP building, which began in October 1989. This 180,000 square-foot facility, scheduled for completion in 1991, has been designed to encourage interdisciplinary collaboration among researchers from seven different departments of science and engineering. CAMP will continue to pursue innovative materials-processing research that will enhance the technological leadership of the University and of CAMP's corporate partners.

For more information, please contact
Edward P. McNamara, Deputy Director
Center for Advanced Materials Processing
Clarkson University
Potsdam, NY 13676
Telephone (315) 268-2336
Fax (315) 268-6438

Facilities and Equipment Available to CAMP Researchers

- Dual chamber plasma reactor
- High temperature chemical vapor deposition reactor
- Excimer laser and 5 kW CO_2 laser
- Molecular beam epitaxy system
- Czochralski and Bridgman crystal growth equipment
- Scanning electron microscope
- Transmission electron microscope
- Atomic absorption spectrometer
- NMR facility
- Image processing system
- Class 10 clean room
- Laser surface scanner
- Laser airborne particle counter
- Intelledex 660 robotic manipulator
- Ion scattering spectrometer and Auger spectrometer
- Blown-film extrusion line (60-inch circumference)
- 50-ton injection-molding machine
- Hydraulic and screw-driven testing equipment
- Complete differential scanning thermal analyzer
- X-ray diffraction unit