Advanced Manufacturing Methods

An increasingly competitive manufacturing environment drives the search for new materials and processing techniques to make them. In most cases, materials processing steps determine the microstructure and performance of the material while manufacturing costs determine price. Industry needs measurement methods, standards, and data that will help monitor, control, and improve processing methods. These tools are also needed to help understand materials processing and to develop new processing methods and materials with enhanced properties. This is as true for highly developed, well-established, industries, as it is for rapidly growing or emerging industries. It is also true for all types of materials, processes, and products. The industrial competitiveness of the United States depends on U.S. manufacturers' ability to use the measurement tools to develop and advance their manufacturing methods. In many cases, the needed tools are generic and their impact would be greatly enhanced if they became industry wide standards. Therefore, MSEL is working to develop measurement methods and standards to enable industry to achieve these goals. This work is often being conducted in close collaboration with industry through consortia and standards organizations. The close working relationship developed with industry through these organizations not only ensures the relevance of the research projects, but also promotes an efficient and timely transfer of research information to industry for implementation. Since different materials and industries frequently have similar measurements needs, and most industrial products have multiple materials components, this program covers the processing of ceramics, metals, and polymers.

Research in the Ceramics Division focuses on development of test methods for the assessment of contact damage and wear, development of test methods and predictive models for evaluation of mechanical properties at elevated temperatures, and development of models for prediction of coating properties and performance. One project focuses on low temperature co-fired ceramics (LTCC), a manufacturing method being developed largely for portable wireless modules because it promises to allow for a reduction in the size and cost of modules used in high frequency applications while improving performance. Because dimensional tolerances are critical in this process, accurate measurements and predictive models of dimensional changes during sintering are necessary for the commercialization of LTCC modules. Measurement methods and predictive models for the overall shrinkage and the local variations in sintering near vias and interconnects are being developed.

Projects in the Metallurgy Division cover several processing and measurement methods. The performance of metallic components in products is strongly dependent on processing conditions that determine microstructural features, such as grain size and shape, texture, the distribution of crystalline phases, macro- and microsegregation, and defect structure and distribution. Expertise is applied from a wide range of disciplines, including thermodynamics, electrochemistry, fluid mechanics, diffusion, x-ray, and thermal analysis, to develop measurement methods and understand the influence of processing steps for industries as diverse as automotive, aerospace, coatings, and microelectronics. Rapidly growing and emerging industries such as biotechnology and nanotechnology are dependent upon the development of new advanced manufacturing methods that can produce metallic components with the desired characteristics and performance. Current projects focus on measurements and predictive models needed by industry to design improved processing methods, provide better process control, develop improved alloy and coating properties, and reduce costs. Important processing problems being addressed include melting and solidification of welds, solidification of single crystals, powder production and consolidation, and coating production by thermal spray and electrodeposition.

Polymeric materials have become ubiquitous in the modern economy because of their ease of processing. However, these materials can exhibit complex and sometimes catastrophic responses to the forces imposed during manufacturing, thereby limiting processing rates and the ability to predict ultimate properties. The focus of the Polymers Division is directed towards microscale processing, modeling of processing instabilities, and on-line process monitoring of polymeric materials. Our unique extrusion visualization facility combines in-line microscopy and light scattering for the study of polymer blends, extrusion instabilities, and the action of additives. Current applications focus on understanding and controlling the "sharkskin instability" in polymer extrusion and observation of the dielectric properties of polymer nanocomposites. Fluorescence techniques are developed to measure critical process parameters such as polymer temperature and orientation that were hitherto inaccessible. These measurements are carried out in close collaboration with interested industrial partners.