The Acquisition of Instrumentation for Microstructural Characterization of Materials That Are Non-Conductive or Include Volatile Phases

Submitted by:

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A thorough characterization of material microstructure is essential to improve the performance of existing materials or to develop new materials for innovative applications. A variety of instruments are available for microstructural characterization, with the scanning electron microscope (SEM) equipped with an energy dispersive x-ray analyzer (EDX) and an orientation image mapping (OIM) system being one of the most popular. However, the application of a SEM for imaging, EDX, or OIM is limited when applied to materials that are not conductive and/or contain volatile phases (NC/VP). Volatilization of these materials can not only damage the SEM, but the results obtained may be negatively affected because the material under evaluation is fundamentally altered as a result of volatilization. These limitations are encountered when using the conventional SEM for characterizing most civil engineering materials, wood products, polymer composites, and some materials used in biomedical applications.

Recent advances in instrumentation have resulted in the development instruments that are uniquely suited for analyzing NC/VP materials. Specifically, two of these instruments are the low-vacuum scanning electron microscope (LVSEM) and the x-ray microscope. In the case of the LVSEM, the sample can be viewed in a relatively high-pressure environment, which acts to dissipate any electrical charge that may develop on non-conductive specimens while minimizing volatilization. The x-ray microscope allows a specimen to be viewed at atmospheric pressure using transmitted and backscattered x-rays, as well as through optical microscopy. X-ray micro-fluorescence can also be performed to determine chemical composition of phases and micro-diffraction can be applied to determine the crystallographic orientation of the same microstructure.

Without question, the ability to characterize NC/VP materials is of paramount importance to a number of disciplines at Michigan Technological University (MTU) including civil, biomedical, and chemical engineering, as well as in wood sciences. Example applications include studies of portland cement concrete failure, observation of asphalt microstructure, investigations of various biomedical engineering materials, and research on various wood composite materials. Tensile/compression and heating/cooling stages are being included to allow for direct observation of deformation in these materials under controlled environmental conditions. A number of projects are planned using these instruments for the development of innovative materials or materials testing methods, including development of new biomedical engineering materials, research in conductive polymer resins, and methods of determining the water to cement ratio in a hardened concrete mixture.

The instrumentation will also result in a hands-on approach to learning for graduate and undergraduate students, as well as provide the opportunity to draw promising high school students into scientific fields of study. In addition to enrolled college students, MTU currently expends great effort to motivate promising high school students to pursue scientific or engineering fields of study, particularly those from underrepresented groups. Because of the versatility and capabilities of this equipment, entertaining and informative sessions are being developed and integrated into these efforts to build enthusiasm amongst high school students.