Optical Imaging and Processing in a SEM/FIB: The Three Beam System

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Combined scanning electron microscope (SEM) and focused ion beam (FIB) microscopes have dramatically changed the market for process control and failure analysis instruments since their introduction over a decade ago. On an industry-wide scale, integration of optical microscopy into these instruments has been minimal. Augmenting SEM/FIB capabilities by the addition of true optical microscopy at the coincidence point of the ion and electron beams provides an additional contrast mechanism, extends the magnification range and introduces capabilities to the FIB/SEM that were formerly confined to bench-top optical microscopes, such as fluorescence microscopy. The combination of particle beam excitation and photon beam detection enables innovative capabilities such as nanometer-scale fluorescence imaging.

Figure 1 shows a schematic drawing of the optical imaging and processing system (OptoProbe™) in a SEM/FIB chamber, as well as a gas injection system. The design of the system enables magnified imaging of the sample surface at the ion/electron beam coincident point, without interfering with normal SEM/FIB imaging modes. The optical system is easily retracted, and the variable working distance is used to determine the field of view. Examples of images from the optical imaging accessory are shown in Figs. 2 and 3.

Previous optical imaging efforts have concentrated on implementing infrared imaging for backside circuit edit applications. These efforts lacked optical magnification, and the field of view and resolution were limited.[1,2] This paper shows optical imaging capability that improves upon previous efforts. In addition to imaging, the OptoProbe™ can also deliver a high fluence laser source for laser-assisted focused electron and ion beam induced etch and deposition processes. Design features as well as imaging and materials processing results obtained from the optical system will be described.

1 P. J. Wolpert, and R. Lee, in *International Symposium for Testing and Failure Analysis*, edited by E. D. F. A. Society (ASM International, Santa Clara, CA, 1999), p. 127.
2 M. A. Thompson, C. Richardson, E. L. Roy, T. Lundquist, and W. B. Thompson, in *International Symposium for Testing and Failure Analysis*, edited by E. D. F. A. Society (ASM International, Phoenix, AZ, 2002), p. 409.

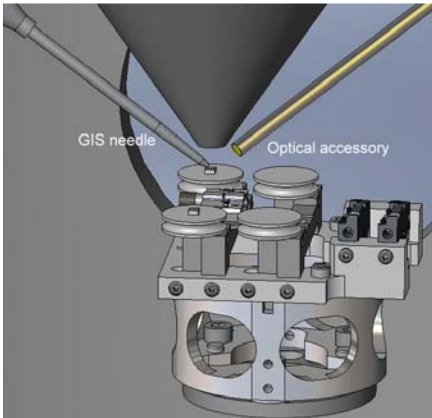

Fig. 1: Optical Imaging and Processing Accessory: The arrangement of the optical system and the GIS needle inside a FIB chamber is shown. Both are inserted and in typical positions for working with a sample.

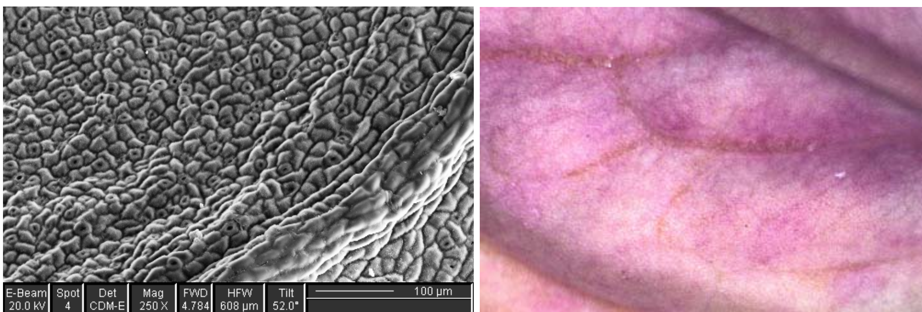

Fig. 2: A Leaf from the Genus Nandin: SEM (left) and optical (right) images, taken at magnifications of 250x and ~50x, respectively.

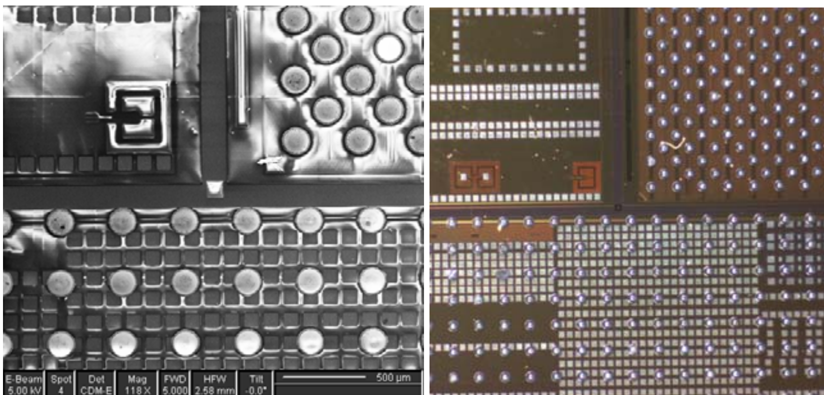

Fig. 3: A Flip Chip Device: SEM (left) and optical (right) images demonstrate the wide optical field of view and navigation opportunities. The SEM image is at the lowest possible magnification (118x).