

SVC Topics

Donald M. Mattox Technical Director Society of Vacuum Coaters 71 Pinon Hill Place N.E. Albuquerque, NM 87122 505/856-7188 • FAX: 505/856-6924 Internet: http://www.svc.org

PVD Processes: Scanning Laser Confocal Optical Microscope

The common optical reflected-light microscope can give magnifications to about 1500X using visual optics with a resolution of about 0.5 microns.1 Major problems with the common optical microscope at high magnifications are the small depth-offield and the high intensity of the reflected light from areas that are not in focus. These problems can be overcome by using a laser light source that allows point-by-point optical scanning of a surface and confocal optics. This sharply reduces the intensity of the light received by the detector from areas not in focus by having a small-diameter aperture in the light path to reject refelcted light from areas not in focus.

Figure 1 shows the optical paths for light from an in-focus plane and an out-of-focus plane in the confocal microscope. Figure 2 shows the resolution and relative intensity of the reflected signal received by the detector as a function of the out-offocus distance for a common optical microscope, and for a confocal laser optical microscope. By allowing only the light from the surface region that is in focus to reach the detector, the image of the surface that is in focus can be scanned, digitized and stored in a series of in-focus layers ("confocal slices").

The focal plane of the confocal microscope is moved in the vertical direction in 100 Å increments using a precision-driven stage. A computer program can be used to give a threedimensional, computer-generated image having a high apparent depth-

of-field. A highresolution scanning laser confocal microscope is capable of better than 0.25 micron resolution on a surface with a precision of 0.01 micron. The vertical resolution is up to better than 0.1 micron, with a precision of 0.03 micron. Commercial confocal microscopes have a vertical range from 0.1 micron to several hundred microns.² The laser light source and confocal optics can be added to many existing optical microscopes. The laser

The laser used for confocal microscopy is generally a 1.5 mW He-Ne (red) laser with an output of 632.8 nanometers. Other



Fig. 1—The optical paths for light from an in-focus plane and an out-offocus plane in the confocal microscope.



Fig. 2—The resolution and relative intensity of the reflected signal received by the detector as a function of the out-of-focus distance for a common optical microscope and for a confocal laser optical microscope.



Fig. 3—Surface of a dressed 1200-grit alumina grinding wheel. Image taken by Lasertec USA Inc.

lasers, such as an excimer laser where the wavelength can be tuned, can also be used. The excimer laser is useful for observing fluorescent materials at a high magnification and at high resolution. True-color images can be produced by projecting red, green and blue laser light down the same optical path. Microscopes can be specially designed to contact portions of large surfaces, such as large panels, curved surfaces and even the inside of largediameter tubes.

The confocal microscope can image any surface that reflects more than a few percent of the incident light. This includes transparent glass surfaces and liquid surfaces. The confocal microscope can be used to examine pitting on the surface of glass windows, for example, as well as corrosion pitting of metal surfaces. The topology of a surface can often be better visualized by using the computer to color-code the height of surface features. Figure 3 shows a picture of the surface (225,485 $\mu^2)$ of a diamond-dressed, 1200-grit alumina grinding wheel taken with a scanning laser confocal microscope. The confocal microscope and its computer program not only give a visual image of the surface, but also can provide information, such as the numerical surface roughness along a linear path on the surface. For the grinding wheel shown in Fig. 3, the surface roughness, R, is 1.38 microns. P&SF

References

- 1. "Metallography and Microstructure," Vol. 9, 9th ed., *ASM Handbook*, ASM International (1985).
- 2. Data taken from Lasertec USA data sheet.

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