Diamond-like carbon (DLC) films are widely used for micromagnetic structures, e.g., read-write heads and magnetic media for information storage, to provide wear protection. The DLC films have variable properties, but for the above applications the films are tailored to be hard and durable for tribology and often have been deposited in thicknesses between 20 and 200 nm. As the information storage capacity is increased on the magnetic structures, the size of features shrink, and now DLC films of 20 nm are used for the current giant magnetoresistive read/write heads. At these thicknesses, it is essential that the DLC provide some corrosion protection as well, and it is the latter that is to be addressed in the present paper. That is, the porosity of the DLC films have been studied with a multifunctional Near Field Optical Scanning Microscope (NSOM) modified to enable scanning electrochemical microscopy concurrent with topography imaging.

Surface characterization with NSOM has matured and is routinely used for studies ranging from biology to materials science. With small apertures to provide illumination, it has been possible to obtain super-resolution imaging in which resolution far below the diffraction limit is achieved. In order to obtain illumination in the “near field”, it is necessary to position the small aperture at a distance that is within the near field. The best resolution that has been obtained is 10 nanometers (1), requires an illumination aperture of 10 nanometers, and a tip-to-surface distance of less than 10 nanometers. The illumination aperture that has the best resolution yet reported has been fabricated by heating and pulling an optical fiber to a tapered tip, and coating the shank of the shaped fiber with aluminum to prevent loss of light from the tip region. The apex of the tip is not coated, so that a small amount of light emerges from the tip. Shear force feedback is used to maintain the small tip-to-surface distance as the tip is scanned over the surface, and this provides a signal with which to monitor the topography of the surface. The topography is characterized currently with optical or other measurements, so that one may associate the two for greater understanding. Surface roughness and surface profilometry measurements are easily available from the digitized image files that are routinely stored in most modern instruments, and thus one may obtain root mean square (RMS) roughness, and peak-to-valley and aspect ratios of individual surface features. The change in the latter measurements is of particular interest for determining the stability and deterioration of surfaces subject to chemical attack.

It is the purpose of the present paper to describe the recent developments in imaging that have been made possible with modifications of NSOM instrumentation to incorporate a quartz crystal tuning fork for feedback control. With the tuning fork modification, an open architecture is produced that can be used with a variety of scanning tips for different types of imaging. Each type of imaging is concurrent with topographic characterization of the surface so that one may associate chemistry with surface features. The combination of SECM and topographic imaging with multifunctional NSOM has been described recently (2,3). When there is porosity of a protective surface film for example, one may image the local electroactivity of the substrate surface that is exposed through holes in the thin overlayer. Examples of model systems will be described in detail, along with a discussion of the prospects for using the same technique for DLC films as thin as 2.5 nanometers.

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References