3D Imaging of Polymers and Bio-Materials Using TOF-SIMS and a C_{60} Ion Microprobe

Gregory L. Fisher

Physical Electronics, 18725 Lake Drive East, Chanhassen, MN 55317

(gfisher@phi.com)

Abstract

In time-of-flight secondary ion mass spectrometry (TOF-SIMS), a focused primary ion beam is rastered over the sample surface and the secondary ions that evolve from the surface are detected as a function of mass-to-charge ratio. The primary ions used to probe the sample surface are most commonly produced by a liquid metal ion gun (LMIG) and consist of species such as Ga^+, Au^+, Au_2^+ or Au_3^+. The ability to probe molecular information at-depth with TOF-SIMS is impeded by the static limit. The static limit is defined as the primary ion dose density (PIDD) beyond which artifacts emerge in the data. For the analysis of organic specimens, the static limit is commonly recognized as a PIDD of $< 3 \times 10^{12}$ primary ions/cm^2. Damage to analyte molecules, or to the sample matrix in general, is often recognized by the degradation of molecular or fragment ion signal(s). A further complexity is that the lateral resolution ($\Delta\ell$) realized in TOF-SIMS does not rely solely on the probe diameter of the primary ion beam but, rather, on the number of secondary ions that are generated from the probed area of the surface. However, simply extending the acquisition time does not necessarily result in better S/N ratio and lateral resolution because damage is simultaneously imparted by the incident primary ions. Thus, the analytical limitations realized by the static limit are grave.

In this presentation, technological and applications developments for advanced characterization of heterogeneous materials and biological specimens will be discussed. The use of C_{60} primary ion beams in TOF-SIMS analysis has led to a significant enhancement of secondary ion yields over those produced by LMIG cluster ion beams. More importantly, though, is the observation that the static limit is abolished for many organic applications. Thus, the ability to probe molecular information at-depth, or beyond the surface region (2 to 4nm) of the sample, is enabled by the use of C_{60} primary ions both for data acquisition and for DC removal of surface material (i.e. sputtering). Indeed, TOF-SIMS characterization of organic materials to a depth of several microns from the sample surface has become routinely achievable. The advantages of using a C_{60} ion microprobe for TOF-SIMS analysis will be demonstrated and explained using real world examples of polymers, biological tissue cross-sections, and biomaterials. The efficacy of a C_{60} ion microprobe for 3D imaging heterogeneous materials will also be discussed using examples of polymers and biomaterials. Lastly, new strategies for depth profiling and 3D imaging of organic specimens will be presented.