

Time-of-Flight Secondary Ion Mass Spectrometry (ToF SIMS)

ToF SIMS analysis involves bombardment of sample surface with pulsed ion beam (Bi^+) and detections of ejected secondary ion species that are characteristic of surface chemistry using Time-of-Flight mass analyzer. It provides both organic and inorganic chemical information directly from solid surface, or vacuum compatible materials. Final data is in the format of mass spectrum to reveal chemical composition and mass spectral imaging to reveal spatial distribution of different species over a selected area. The information depth is the top 1 to 2 nm for surface spectrum and image acquisition. The detection limit for ToF SIMS is generally better than other surface analysis technique, which is on the order of 0.1% - 0.01% atomic concentration.

ToF SIMS is useful for trace analysis, contamination screening, diffusion between layers, adhesion failure analysis. Materials can be analyzed including metals, semiconductors, polymers, paints, coatings, glass, paper, wood, fabrics, ceramics and pharmaceuticals etc.

There are three analysis modes in ToF SIMS. The first one is high mass resolution spectrum, which offers 8000 $m/\Delta m$ mass resolution. The detector collects exact mass of the ejected secondary ions. In this mode, one can easily separate Si^+ (m/z 27.9764) and C_2H_4^+ (m/z 28.0308). Isotopes of elements can be collected. The surface is not destroyed due to small ion current density. This is so-called "static SIMS".

The second one is high spatial resolution mass spectra images. This data is a chemical map of different species as a function of spatial position. Spatial resolution can be achieved with 300 nm. The ion maps reveal the relative concentration of the specific species. In this mode, the surface is also not destroyed due to small ion current density.

The third one is depth profile, which is a destructive analysis. With a sputtering ion gun, materials can be etched or sputtered while analyzed. One can get elemental or molecular information as a function of depth. Depth resolution can be achieved with a few nm.

Since secondary ion yield of different species can range a few order of magnitude and ToF SIMS analysis involves organic fragments, this method is usually a qualitative but not a quantitative analysis. With known implants of species of interests, quantification for species below 5% atomic concentration can be achieved.