What is ToF-SIMS?
The Secondary Ion Mass Spectrometry (SIMS) is the mass spectrometry of ionized particles which are emitted from the surface when energetic primary particles bombard the surface. The mechanism of TOF-SIMS is shown in the following illustration. The pulsed primary ions with the energy of 1-25keV, typically liquid metal ions such as Ga+, Cs+ and O−, are used to bombard the sample surface, causing the secondary elemental or cluster ions to emit from the surface. The secondary ions are then electrostatically accelerated into a field-free drift region with a nominal kinetic energy of:

\[ E_k = eV_0 = \frac{eV_0}{m} \]

Where \( V_0 \) is the accelerating voltage, \( m \) the mass of ion, \( v \) the flight velocity of ion, \( e \) its charge, you can see from the above formula that the ion with lower mass has higher flight velocity than one with higher mass. Thus they will reach the secondary-ion detector earlier. As a result, the mass separation is obtained in the flight time \( t \) from the sample to the detector. The flight time \( t \) is expressed by:

\[ t = \frac{L}{(2eV_0/m)^{1/2}} \]

Where \( L \) is the effective length of the mass spectrometer. A variety of mass ions are recorded by the detector with the time sequence to give the SIMS spectrum.

The early-stage spectrometer is operated in a mode of dynamic SIMS (DSIMS). The DSIMS directs a high flux of primary ion to the sample surface, eroding the surface rapidly. Therefore, DSISM is not suitable for ultra-thin surface analysis. A static SIMS (SSIMS) was developed in 1970’s. PHI TRIFT III is a cutting-edge SSIMS, which directs a primary ion beam with a very low current density to the outmost surface (~5 Angstrom) so as to main the surface integrity for a long period in excess of the analysis time. Typically, the primary ion dose in the SSIMS mode is \( \leq 10^{12} \text{ ions/cm}^2 \) for mass analysis and \( \leq 10^{13} \text{ ions/cm}^2 \) for imaging. Under such a condition, the lifetime of the monolayer can keep over several hours to tens of hours. SSIMS is the most sensitive technique for elemental analysis, which allows it to detect the trace impurity. SSIMS is used to analyze not only the elemental composition but also the chemical structure of surface.

[Reference: Robert Braun, Evans PHI, and operator’s guide, Physical Electronics]