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Ultra-high depth resolution MCsn+-SIMS for direct compositional analysis of low-dimensional structures of condensed matter systems

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Excellent detection sensitivity, high dynamic range and good depth resolution make the secondary ion mass spectrometry (SIMS) extremely powerful for the analysis of surfaces and interfaces of materials. However, a serious problem in SIMS analysis is its "matrix effect"that hinders the materials quantification. Realistic SIMS quantification having analytical accuracy better than ±20% requires the analysis of standard samples of the impurity species in the chemical matrix of interest. These standards are necessary because secondary ion yields depend on both the impurity species and its chemical environment. Different chemical matrices have different sputter ion yields and thus, the ion yields for a given element or molecule may vary significantly depending on the chemical matrix. This ion yield variation, known as "SIMS matrix effect", is a function of the electronic (and vibrational) states of both the sputtered species and the surface as well as the chemical bonding of the species to the surface. Ion yields in SIMS can vary by several orders of magnitude, thus effectively preventing quantitative SIMS analysis.

Corrective measures are therefore needed to calibrate the secondary ion currents into respective concentrations for accurate compositional analysis. Working in the MCs+-SIMS mode (M –element to be analyzed, Cs+ –bombarding ions) can circumvent the matrix effect. The emission process for the species M0 is decoupled from the MCs+ ion formation process, in analogy with the ion formation in secondary neutral mass spectrometry (SNMS), resulting in a drastic decrease in matrix effect in the MCs+-SIMS mode. Although this technique has found its applicability in direct quantification, it generally suffers from a low useful yield. In such cases, detection of MCsn+ (n = 2,3,. . .) molecular ions offers a better sensitivity (even by several orders of magnitude) as the yields of such molecular ion complexes have often been found to be higher than that of MCs+ ions. Several works have been reported on the emission of MCsn+ molecular ions, but a complete understanding on the formation mechanisms of these ion complexes is still lacking. The MCsn+-SIMS technique in all its complexities has great relevance in the analysis of materials. The talk will address on the possible formation mechanisms of MCsn+ molecular ion complexes and their applications in interfacial analysis of ultra-thin films, metallic multilayers, semiconductor superlattices, quantum wells and compositional analysis of MBE - grown Si1-xGex alloy structures. Our division has made significant contributions in ion-solid interactions in general and ion microbeam analysis of surfaces and interfaces of a wide variety of condensed matter systems in particular. Our focus is the controlled growth, characterizations and modifications of low-dimensional structures with tunable morphology and properties. The talk will also touch upon the glimpses of some of our important activities.

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