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Alkali containing molecular-ion based SIMS: Fundamentals and potential applications in the chemical analysis of low-dimensional materials

If alkali metals such as Cs, Li, Rb, K, Na, etc. (referred as A in general) are present in the neighborhood of the probing element (M) on a sample surface, quasi-molecular ions can be formed by the attachment of these alkali ions [(MA)+ formation] in the secondary ion mass spectrometry (SIMS) process. Formation of these MA+ molecular ions has a strong correlation to the atomic polarizability of the element M. The emission process for the re-sputtered species M0 is decoupled from the MA+ ion formation process, in analogy with the ion formation in secondary neutral mass spectrometry (SNMS), resulting in a drastic decrease in the conventional 'matrix effect' in SIMS. Although the detection of MA+ molecular ions in SIMS has found its applicability in direct materials quantification, it generally suffers from a low useful yield. In such cases, detection of (MA)n+ (n=2, 3,….) molecular ions offers a much 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 MA+ ions. The recombination coefficient of MA+ or MA2+ molecular species depends on the electro-positivity or electro-negativity of the element M, respectively. Apart from the surface binding energy of the respective uppermost monolayer, the changes in local surface work-function have often been found to play a significant role in the emission of these molecular ions. Although these MAn+ molecular-ion based SIMS has great relevance in the analysis of materials, a complete understanding on the formation mechanisms of these ion-complexes is still lacking. A procedure, based on MAn+-SIMS approach, has been proposed for the accurate germanium quantification in molecular beam epitaxy (MBE)-grown Si1−xGex alloys. The 'matrix effect' has been shown to be completely suppressed for all Ge concentrations irrespective of impact Cs+ ion energies. Cesium, the fifth alkali element, is the most reactive of all the metals. The methodology has successfully been applied for direct quantitative composition analysis of various thin film and multilayer structures. Recent study on various ZnO-based nanostructures has successfully been correlated to their photo-catalysis and photoemission responses. The present talk will address the complex formation mechanisms of MAn+ molecular ions and potential applications of the MA+-SIMS approach in chemical analysis of low-dimensional materials and nanostructures.

Biography

Purushottam Chakraborty is a senior professor at Saha Institute of Nuclear Physics, Kolkata, India and an honorary professor at the University Of Pretoria, South Africa. His research interests range from 'ion beam analysis of materials' to 'x-uv optics and photonics'. He worked at many renowned centres like FOM – Institute for Atomic and Molecular Physics, Padova University, ICTP, Laval University, Osaka Electro-communication University, etc. He has published more than 125 papers including reviews and book-chapters. He has been awarded the 'most eminent mass spectrometrist of India' and is one of the world leaders in Secondary Ion Mass Spectrometry (SIMS).

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