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Alkali containing molecular ions in SIMS: Understanding of the emission phenomena

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If alkali metals such as Li, Rb, K, Na, etc. (referred as A in general) are present in the neighbourhood 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 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 MA_2^+ 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 $Si_{1-x}Ge_x$ alloys. The 'matrix effect' has been shown to be completely suppressed for all Ge concentrations irrespective of impact Cs^+ ion energies. 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 talk will address the complex formation mechanisms of MA_n^+ molecular ions and potential applications of the MA^+-SIMS approach in chemical analysis of low-dimensional materials.

Biography

Purushottam Chakraborty is an Ex-senior Professor at Saha Institute of Nuclear Physics, Kolkata, India and an honorary Professor at University of Pretoria, South Africa. He is one of the leading SIMS expert of the world and has published more than 150 scientific papers and numerous reviews and book-chapters. He was awarded the most eminent Mass Spectrometrist of India in 2003.

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