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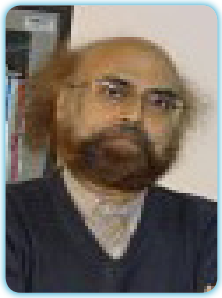

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MCs_n+-SIMS: An inventive secondary ion mass spectrometric (SIMS) approach for exact composition analysis of quantum structures

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 low-dimensional materials. Our focus is the controlled growth, characterizations and modifications of low-dimensional structures with tunable morphology and properties. However, a serious problem in SIMS 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 the instantaneous surface chemistry of the sample. This ion-yield variation, known as "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 atomic concentrations for accurate compositional analysis. Working in the MCs+-SIMS mode (M-element to be analyzed and 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 MCs^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 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 MCs^n+-SIMS technique in all its complexities has great relevance in the analysis of materials. A procedure for the accurate quantification of Ge concentration in MBE-grown Si_1-xGe_x ($0<x<0.72$) alloys, based on MCsn+-SIMS approach, has been proposed. 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 Si/Ge multilayer structures. The talk will address the various possible formation mechanisms of MCs_n+ molecular ion complexes in sputtering process and the fascinating applications of the MCs_n+-SIMS approach for the interfacial analysis of ultra-thin films, superlattices, quantum wells and for compositional analysis of MBE -grown Si_1-xGe_x alloy structures.

Biography

Purushottam Chakraborty was a Senior Professor of Saha Institute of Nuclear Physics, India till 2015 and is currently a Visiting Professor of Physics at Sultan Qaboos University, Muscat, Sultanate of Oman. He has completed his PhD from Calcutta University and did his Post-doctoral research at FOM-Institute for Atomic and Molecular Physics in Netherlands, Padova University in Italy and Laval University in Canada. He was associated with the Osaka Electro-Communications University, Japan, University of Pretoria, South Africa and Friedrich Schiller University, Germany as a Visiting Professor of Physics. He has authored more than 150 scientific papers including book-chapters and review articles. He was awarded the most Eminent Mass Spectrometrist of India in 2003.

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