Stevens Institute of Technology

Nanotechnology Graduate Program

Nano Scale Chemical Characterization at NIST: Imaging Mass Spectrometry, Cluster Beams, Drug Delivery and Homeland Security

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There is great interest in the development of cluster primary ion beams for applications in secondary ion mass spectrometry (SIMS), motivated by several unique aspects of the interaction between energetic cluster ions and surfaces. When a cluster ion strikes a surface, it dissociates into its constituents atoms, each of which retains a fraction of the initial energy of the cluster ion. For example, a C_{60}^+ cluster ion with an impact energy of 3000 eV would dissociate after impacting the target surface into 60 carbon atoms each with an impact energy of only 50 eV. Since the depth resolution of a SIMS depth profile is directly related to the primary projectile energy, the use of a cluster ion should provide a method for obtaining ultra-high resolution SIMS depth profiles. The dissociation of a cluster ion also leads to multiple individual primary particle impacts that are correlated both temporally and spatially. This results in a localized deposition of energy in the near-surface region of the sample leading to a several order of magnitude enhancements in the number of atoms or molecules desorbed from a surface by each cluster impact. Also, for some organic materials, the accumulation of primary beam-induced damage is minimized allowing stable characteristic molecular ion signals to be obtained at high primary ion doses (dynamic SIMS conditions). For the past several years we have been involved in an effort to develop a capability for polyatomic primary beam SIMS on both magnetic sector and time-of-flight SIMS instruments. Several types of cluster ion sources are currently being used for this project including SF_5^+, C_8^-, C_{60}^+ and Bi_3^+. To illustrate some of the unique advantages of using cluster SIMS for surface analysis we will show results for analysis of semiconductor surfaces, metal films, organic thin films, drug delivery systems, biological tissue and energetic materials. Our recent efforts have been focused on combining cluster SIMS depth profiling with secondary ion imaging to provide true 3 dimensional molecular analysis of organic thin films and drug delivery systems. We have also utilized cluster SIMS to examine energetic materials (explosives) for the Department of Homeland Security. These experiments have led to the initiation of a new research efforts focused on the analysis of high explosive particles for airport security screening.

Dr. Greg Gillen graduated from the University of California Santa Barbara in 1983 with a BS in Chemistry and a PhD in Analytical Chemistry from Arizona State University in 1987. He joined NIST as a Postdoctoral Research Associate in 1988 and became a staff scientist in 1989. He is currently group leader of the NIST Analytical Microscopy Group. His research interests include surface analysis, microscopy, ion solid interactions, biological and organic mass spectrometry, ion mobility spectrometry, secondary ion mass spectrometry, inkjet printing and trace explosives detection. He is co-founder and organizer of the "Annual Workshop on Secondary Ion Mass Spectrometry" and the "Annual Workshop on Trace Explosives Detection". He was the recipient of Department of Commerce Bronze and Silver Medals for research for research related to SIMS. He is a member and former chairman of the ASTM E42.06 subcommittee on Secondary Ion Mass Spectrometry and has served on the board for the Applied Surface Science Division of the American Vacuum Society. He has published ~100 scientific papers and conference proceedings on various aspects of surface analysis and has given numerous presentations at national and international conferences. His most recent research has focused on development of a standards and metrology program for trace detection of explosives and narcotics.

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