

# Fundamentals of Cluster Ion Beams in SIMS

Andreas Wucher \*

Department of Physics, University of Duisburg-Essen, D-45117 Essen, Germany  
wucher@uni-essen.de

The application of cluster ion beams as desorption probes appears to be a major breakthrough in molecular SIMS. The general observation is that secondary ion yields, particularly those of complex molecular species, are significantly enhanced and mass spectra are greatly simplified if polyatomic projectiles are employed instead of atomic species. Apart from the sensitivity increase, the high sputter yield associated with the cluster/solid interaction also appears to allow for molecular depth profiling studies without the accompanying damage accumulation normally associated with atomic bombardment. It is particularly this property which opens new roads towards high resolution three dimensional chemical characterization of complex structures like organic thin films, arrays or even single biological cells.

During the recent years, the emergence of commercially available cluster ion guns with good beam quality and sub-micron imaging capability has dramatically propelled applications of this technique. In fact, the rapidly growing body of published work leads one to expect that cluster beams will be routinely used in SIMS experiments in the very near future. The fundamentals behind the observed improvements, on the other hand, are not yet clear, although details are emerging quickly. For instance, a basic question that must be resolved is to determine whether the observed secondary ion yield enhancement occurs as a consequence of increased ionization efficiency, or is due to a more effective desorption process. In that respect, the presently available data appear to be mixed, indicating that both effects may contribute in different proportions depending on the specific projectile/target combination. Moreover, the mechanisms leading to the apparent reduction of bombardment induced chemical damage accumulation must be elucidated. In a simplified picture, one might assume that due to the high sputter yield or total desorption rate induced by cluster projectiles, damaged material may be removed from the surface with comparable rate as how it is created. A systematic proof of this concept, however, appears to be still lacking. Other observed cluster beam effects, including improved depth resolution in depth profile analysis, surface smoothing by cluster bombardment etc., still remain largely unexplained.

The talk will attempt to briefly draw together the extensive work addressing these questions that has been gathered by many groups during the past decade. Particular emphasis will be given to a few recent developments that may serve to illustrate some of the basic concepts behind the magic of cluster SIMS.