SUMMARY

This project will develop a secondary ion mass spectrometer (SIMS) with higher sensitivity than current commercial SIMS and also with better depth resolution. The key technological improvement is the use of multicharged ion (MCI) pulses generated from a compact laser ion source as the primary beam. Current commercial SIMS uses singly-charged ions or clusters for the primary beam, which causes secondary ion ejection by collisional sputtering from the surface of a sample. Multicharged primary ions with high potential energy cause potential energy sputtering in addition to collisional sputtering, in which the ionization fraction for the secondary beam can be two-to-three orders of magnitude higher than for singly-charged ions or clusters. The higher ionization fraction results in a corresponding increase in SIMS sensitivity and depth resolution. A pulsed laser will be used to ablate bismuth or gold targets, producing an intense source of MCIs. These ion pulses will be accelerated and shortened to a few nanoseconds. Then, a specific charge will be selected and incident on the sample to be analyzed. A time-of-flight ion spectrometer will be built to identify the mass of the secondary ions. The instrument sensitivity, mass resolution, and depth and lateral resolutions will be tested under static and dynamic SIMS. The MCI-SIMS will enable elemental depth profiling of shallow-implanted dopants, identification of the composition of the surface region of thin films and ultrathin layers with much reduced pre-equilibrium region and mixing effects, and nanoscale ion implantation for implantation-based quantum devices. The instrument will enable further research on MCI interaction with surfaces and the study of synergy between MCI-surface interaction and laser surface excitation. At least three Ph.D. students will be involved in the development of the MCI-SIMS, while many faculty and graduate and undergraduate students will utilize the instrument once it is commissioned. Also, over the four years, 20–24 Old Dominion University undergraduate students will participate in the project as part of their engineering capstone senior design and physics senior thesis, and 2–4 University of California-Berkeley undergraduate students will be introduced to particle-in-cell simulation as undergraduate research.