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Nondestructive and Quantitative Depth Profiling Analysis of Ion Bombarded Surfaces by Medium Energy Ion Scattering Spectroscopy.

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Ion beam sputtering has been widely used for sputtering depth profiling with XPS and AES. However the problem of the surface compositional change due to ion bombardment has remained to be understood and solved. So far sputtering processes have been usually studied by surface tools such as XPS, AES, LEISS, and SIMS or by analyzing sputtered particles as in SNMS. Calculated results by Monte Carlo Simulation and Molecular Dynamics Results have been compared with the experimental results. However, no direct analysis of surface layers and sub-surface layers damaged by ion beam bombardments have been made.

In this work, a Medium Energy Ion Scattering Spectroscopy (MEIS) system was constructed which can have the depth resolution of better than 10 Å. With the MEIS system, the altered surface layers and sub-surface layers of amorphous Ta_2O_5 thin films due to Ar^+ ion bombardment was depth profiled nondestructively and quantitatively, for the first time as a function of the ion incidence angle, the ion energy, the primary ion species, and the ion dose. The depth resolution was good enough to observed the depth distribution of Ta atoms in the oxygen depleted zone under various ion bombardment conditions.

The MEIS spectrum showed that the oxygen depleted depth is 30Å under normal incident 3 keV Ar^+ ion bombardment and it decreases continuously with the incidence angle to 15Å under the 80^0 glancing incidence angle. The increased Ta concentratin at the surface due to preferential sputtering of oxygen atoms was about 47% under normal incident 3 keV Ar^+ ion bombardment and about 20% under 80^0 glancing incidence. The altered zone was saturated in the ion dose of $3x10^{16}$

ions/cm^2. With the increase of the ion energy from 1.5 keV to 5 keV, the depth of oxygen depleted zone increased from 15 Å to 40Å. With oxygen ion beam bombardment, it was found that the oxygen depletion did not occur compared to argon ion bombardment in consistent with our former XPS results.[1]

The above MEIS experimental results are compared with XPS results in good agreements, as well as with the Monte Carlo Simulations. The first quantitative and nondestructive MEIS analysis of ion beam bombarded surface layers including sub-surface layers should be very useful to improve our understanding of sputtering processes.

1. D.W.Moon and K.J.Kim, APL, 62,3094 (1993).