特別講演要旨

Medium Energy Ion Scattering Spectroscopy for Quantitative and Ultra-High Resolution Depth Profiling: Possibilities and Problems

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For most of the common surface analysis methods, the analysis results are sensitive to the sample matrix and therefore the use of standards is required. Especially for the surface analysis techniques involving sputter depth profiling, it has been well recognized that the surface damage problems like ion beam mixing and surface topographic development deteriorate the quantification and the depth resolution. Recently developed Medium Energy Ion Scattering Spectroscopy (MEIS) is the high resolution Rutherford Backscattering Spectroscopy with the depth resolution compatible to those of common surface analysis techniques.

In this work, the possibility of MEIS as a quantitative and ultra-high resolution depth profiling technique of ultra thin films was studied so that it can be used for improvement of the quantification of the surface analysis techniques. MEIS has a couple of special features that can have very important significance in the surface analysis society.

First of all, MEIS analysis results are not sensitive to the sample matrix like RBS. In addition to this, MEIS can depth profile the surface and the subsurface layer with the depth resolution of a couple of atomic layers without sputtering and subsequent surface damage problems. Therefore there is a good possibility that MEIS can provide a good reference for compositional analysis of surfaces. One of the expected problems can be the poor knowledge of the interatomic potentials, especially for high Z elements which is important to calculate the cross section of ion scattering. The effect of surface morphology could be an additional problem. The poor mass resolution problem of proton MEIS can be resolved by using heavier ions. Heavy incident ions can also increase the sensitivity of MEIS, since the scattering cross section is proportional to the square of the atomic number of the incident ions.

At present, the depth resolution of MEIS is practically a couple of atomic layers at surface, which is compatible to the sampling depth of most common surface analysis tools. By using glancing incidence angles or improving the energy resolution of the energy analyzer with smaller slit width, single atomic layer depth resolution was reported. Another possible approach to improve the depth resolution is using heavy incident ions, since the electronic energy loss is proportional to the square of the atomic number of the incident ions. Even though the electronic energy loss for proton is fairly well tabulated, the value for heavier ions requires further investigations to improve the accuracy. To obtain informations on the interfaces located deep below the surfaces, the electronic straggling problem should be clearly understood. For the electronic straggling, the situation is worse. Even for the proton, the Bohr values are overestimated by a couple of 10 %. Therefore to establish MEIS as a quantitative and ultra-high resolution depth profiling techniques that is accurate enough to provide references for

surface and interface analysis, those problems mentioned above should be thoroughly understood and solved.

To assess the analytical capabilities of MEIS, it was applied to analyses of 10 nm Ta2O5/Si. To optimize the MEIS analysis conditions for improving the depth resolution, the sensitivity, and the mass resolution, the samples were analyzed with various incident ions such as 100 keV H+, Li+, N+, Ne+ ions. Increasing the incident ion mass improved the depth resolution, the sensitivity, and the mass resolution significantly. However, the Ne+ ions have the serious neutralization problem. The best depth resolution of about .6 nm at the surface of 10nm Ta2O5/Si was obtained with 100 keV N+ ions. The measured electronic stopping power and the electronic straggling will be evaluated with the present available theory. With 100 keV H+ ions, the meaningful probing depth was estimated to be around 40nm for a (10nm SiO2/ 10nm Ta2O5) 4 multilayered thin film on Si. For the deeper region, probably the neutralization problem decreases the scattered ion intensity and the straggling problem made the spectrum diffused seriously. To improve the sensitivity of the MEIS, heavy ions like Ne+ ions were used. With 100 keV Ne+ and 200 keV Ne++ ions, the profile of 30 keV Ta+ implanted into Si (1.0x1015/cm2) could be profiled successfully. This capability should be very useful in depth profiling of shallow junctions. With 100 keV Li+ ions, the mass resolution was quite improved compared with proton so that the Pt and Co peak was separated completely. The surface compositional change of a 1:1 Pt-Co alloy was depth profiled with 100 keV Li+ ions, which showed an increase of Pt concentration at the surface. The above described MEIS analysis results were compared with corresponding AES depth profiling, XPS analysis, and SIMS analysis. Discussions will be given on how MEIS can be improved and utilized to investigate basic questions like what really is measured with the surface sensitive techniques especially after sputtering and how to get the original informations on the surface and interfaces of thin films.