Measurement of scattering spectra for medium energy Ne⁺ incidence in ERDA geometry

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Elastic recoil detection analysis (ERDA) is well known as a powerful technique for the detection of light elements, especially hydrogen. Conventional ERDA methods have been widely used to measure the absolute amount and depth distribution of hydrogen using high-energy helium or heavy ions with an absorption foil in front of the silicon surface barrier detector. Absorption foil is useful in removing forward-scattered incident ions and allowing only recoil hydrogen to pass through, but reducing the depth resolution. We have previously proposed a direct detection method using a toroidal electrostatic analyzer with medium energy Ne⁺ ion injections and have reported the excellent sensitivity for the detection of hydrogen at the top surface of Si [1]. In the case of direct detection, the yield of scattered incident ions needs to be accurately estimated because the yield is counted as background. However, since there are few examples of measurements of Ne spectra in ERDA geometry, we performed the measurements and Monte Carlo simulations using the

SRIM (The <u>Stopping</u> and <u>Range</u> of <u>Ions in Matter</u>) code [2].

The experiments were performed at beamline 8 named SORIS set up at SR Center. Single crystal Au and Si were employed as samples, and 143.46 keV Ne⁺ ions were used as incident ions. The random direction of incidence was carefully determined by azimuth angle scanning. Observed forward-scattering spectra from random and planar channeled incidence on Au are shown in Figure 1. Here, the incidence angle was set to 60° with respect to the



Fig. 1. Forward scattering spectra from random and planar channeled incidence on Au single crystal. Black and red arrows indicate recoil Au⁺ and recoil H⁺, respectively.

surface normal and the scattering angle was set to 45°. In the planar channeled spectrum, the yield reduction due to channeling effects, and surface peaks can be seen. Figures 2 (a) and (b) show the measured and simulated forward scattering spectra for Au and Si, respectively. The blue arrows in the figure indicate the scattering peaks from the top surface, and the subscripts indicate the charge state of Ne. For both Au and Si samples, the charge states of Ne⁺, Ne²⁺, and Ne³⁺ can be confirmed. In addition, strong multiple scattering effects are observed in the broad tail on the higher energy side than the energy indicated by Ne⁺ arrow in fig. 2 (b). The simulated spectra were reproduced by the SRIM calculation results, which were the energy and emission direction of the Ne ions scattered from the target surface into the vacuum. Furthermore, two models (M&Y [3] and CasP [4]) for the charge state distribution of Ne ions were added to the calculations. The simulated spectra generally reproduce the measured spectra. The M&Y model is in better agreement for Au, and the CasP model for Si. The red arrows in figure 2 (a) and (b) show the recoil energy of hydrogen at the top surface. In this energy region, the scattering yield, which is the background for the detection of hydrogen by ERDA, is about 20 times higher for the Si substrate than for the Au substrate.



Fig. 2 (a) and (b). The measured and simulated forward scattering spectra for Au and Si, respectively. The blue and red solid lines show the results from CasP and M&Y, which are models of the charge state distribution of Ne, respectively.

References

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