Highly sensitive hydrogen detection for metal surfaces by medium energy Ne^+ impact

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1. Introduction

It is well known that hydrogen affects the properties of various kinds of materials such as hydrogen embrittlement. Recently, hydrogen storage has attracted much attention for application to automobile driving with fuel cells. There are a variety of methods to detect hydrogen proposed so far, such as secondary ion mass spectrometry(SIMS), elastic recoil detection analysis(ERDA) and induction coupled plasma(ICP). Unfortunately, the sensitivity to hydrogen is not so high because of significant background levels. In this study, we show that medium energy Ne^+ impact gives an excellent sensitivity to H on metal surfaces. The reason for the high sensitivity to hydrogen is simply explained by the fact that the H^+ fraction is much larger than the Ne^+ fraction as well as the fractions of singly ionized substrate atoms recoiled from the surfaces.

2. Experiments

The experiments were performed at beamline 8 named SORIS, which were set up at Ritsumeikan SR Center[1]. A duo-plasma ion source provided intense $^{20}Ne^+$ beams with a good emittance, which were accelerated from 5 up to 200 keV. Recoiled H^+ ions were energy-analyzed with a troidal electrostatic analyzer (ESA) and then incident on a three-stage micro-channel plate combined with a position sensitive detector with an excellent spatial resolution of 40 μm, leading to $\Delta E/E \cong 1\times10^{-3}$(FWHM). In order to avoid radiation damage of the sample surface, we shifted the beam position on the surface after accumulating a beam current of 0.05μC. We employed Au(111) crystal, SUS plate and Si(111) wafer as analysis samples.

3. Results and Discussion

Figure 1 shows the ERDA spectra observed at an incident angle of 50° for 146.46 keV Ne^+ incident on as-prepared Si(111) (black lines), SUS plate (red lines) and Au(111) (blue lines), respectively, where the H^+ ions recoiled to 85° with respect to surface

normal were detected. Unexpectedly, the hydrogen atoms adsorbed on the surfaces were clearly detected in spite of much larger scattering cross sections and abundance for the substrate atoms. This is ascribed to the fact that Ne^+ fraction and the fractions of singly-ionized substrate atoms recoiled from the surfaces are much smaller than H^+ fraction. The primary background of Ne^+ decreases pronouncedly with increase in the mass of constituent atoms of the substrates. This indicates strong dependence of Ne^+ fraction upon substrate materials. The sensitivity to hydrogen on Si(111), SUS and Au(111) substrates is estimated to be 2.0×10^{14} H/cm^2, 1.0×10^{14} H/cm^2 and 3.0×10^{13} H/cm^2, respectively.

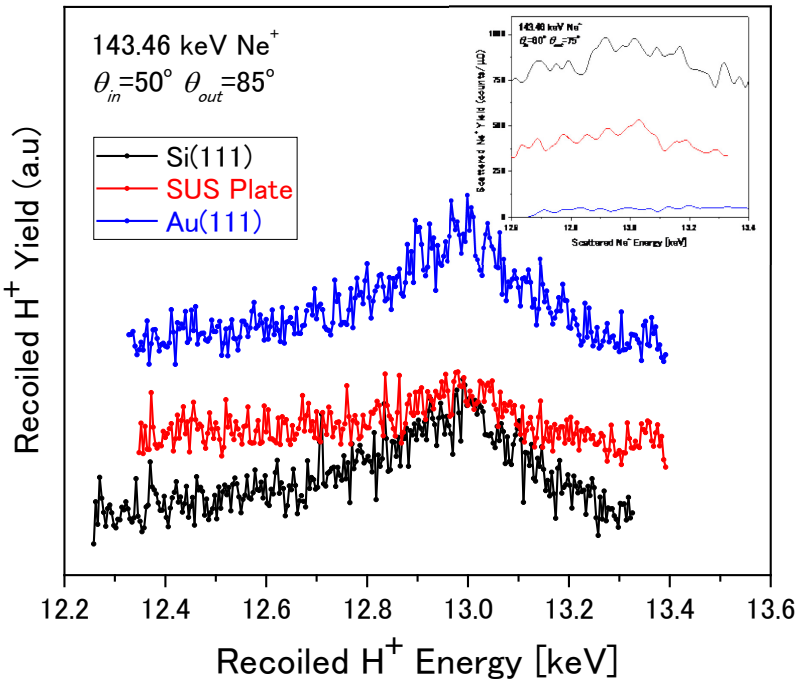

Fig.1 ERDA spectra observed for 143.46 keV Ne^+ ions incident on Si(111) (black lines), SUS plate(red lines) and Au(111) (blue lines), respectively. Inset indicates background spectra observed for 143.6 keV Ne^+ ions incident to 60° and scattered

Reference

[1] Y. Kido, T. Nishimura, Y. Hoshino, and H. Namba, Nucl. Instrum. Methods **B 161–163** (2000) 371.