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The resonant ^{16}O(alpha, alpha) ^{16}O measurement using RBS system at KOMAC

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1. Introduction

Rutherford Backscattering Spectrometry (RBS) is a non-destructive surface analysis method. The thickness and composition of target material can be obtained by measuring the energy of backscattered alpha particle.

RBS measurement can be performed using 1.7MV tandem accelerator at Korea Multi-purpose Accelerator Complex (KOMAC). The accelerator was first installed at Korea Institute of Geoscience and Mineral resources (KIGAM) in 1980s and moved to KOMAC in 2015.

The ion implantation experiments, using 1.7 MV tandem accelerator, has been conducted since 2016. And RBS measurement test service will begin on this autumn. The composition and thickness of target material can be obtained using our RBS system. However, the mixture of light elements (C, N, O) is hard to distinguish using conventional RBS measurement. Oxygen content in the mixture of light elements can be measured using the resonant ^{16}O(alpha, alpha) ^{16}O scattering. The method will be introduced in this paper.

Figure 1. 1.7 MV tandem accelerator at KOMAC

2. Experimental

Figure 1 shows the 1.7 MV tandem accelerator at KOMAC. The accelerator has two ion sources (SNICS, RF source; http://pelletron.com), high voltage terminal (high pressure tank), and four beam lines. RBS measurement was conducted using RF source, high voltage terminal, and RBS beam line. The ions from hydrogen to uranium can be generated theoretically using SNICS and RF source. In case of hydrogen ion, the maxium energy was 3.4 MeV and the maximum current was 2 uA at the sample holder. Many users have used hydrogen implantation for various applications.

The alpha particle can be generated using RF source. The maxium beam current (alpha) at the sample holder can be increased above 20 nA. However, in order to prevent collecting pile-up signal and sample damage, the beam current was maintained below 20 nA. The energy of alpha particle, used in RBS measurement, was varied from 2 to 3.1 MeV. The geometry of RBS measurement was showed in Fig 2. The incident and scattering angle was 5° and 170°, respectively.

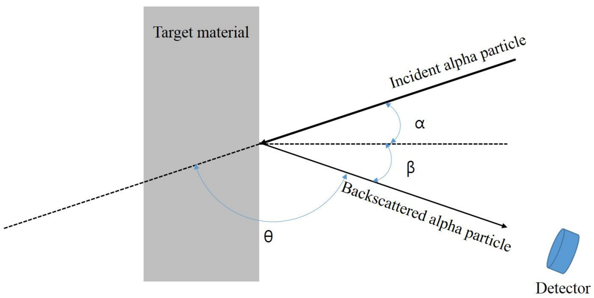

Figure 2. Geometry of RBS experiment. Incident angle α, exit angle β and scattering angle θ.

Two types of sample was used in this experiment. One is SiO_2 on Si substrate (type 1), and the other is Co(20nm)/Pt(20nm)/SiO_2(100nm)/Si substrate (type 2). Type 1 sample was for the energy calibration for RBS system. The complex structure (type 2) was also analyzed using the resonant ^{16}O(alpha, alpha) ^{16}O scattering.

The Obtained data was analyzed using SIMNRA simulation (http://www.simnra.com). Before the experiment, the resonant scattering behavior was also simulated using SIMNRA.

3. Results

First, the conventional RBS measurement for type 1 sample was performed as shown in Fig 3. The energy of alpha particle was 2MeV. The broad and un-distinguishable peak (channel 250 to 330) is related with oxygen. As shown in Fig 3, the conventional RBS system is hard to distinguish the oxygen within light elements.

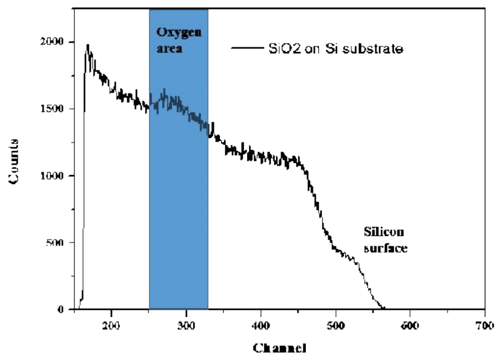

Figure 3. The conventional RBS spectrum of SiO2 on Si substrate.

When the resonant ^{16}O(alpha, alpha) ^{16}O scattering is used, the oxygen content can be obtained. Because the scattering cross-section between alpha particle and oxygen atom significantly increase at the particle energy of 3.032 MeV.[1] Figure 4 shows the simulation of the resonant ^{16}O(alpha, alpha) ^{16}O scattering.

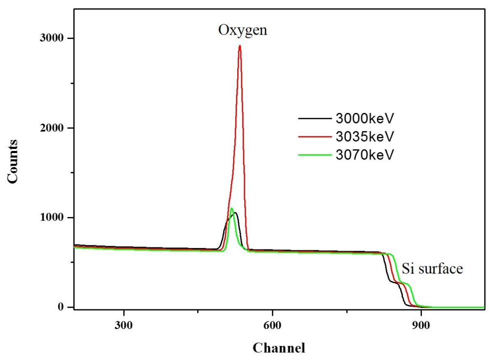

Figure 4. Simulation results of the resonant scattering.

When the 3.035 MeV-alpha particle was used, the oxygen intensity was significantly increased. The oxygen (and/ or other light element) analysis can be conducted using the resonant scattering. The resonant scattering experiment for two samples will be done and the result will be presented.

4. Conclusion

The conventional RBS measurement has drawback such as the oxygen analysis. The resonant scattering experiment is a good option for the light element analysis. The two sample will be analized using the conventional RBS and the resonant scattering. The oxygen contents of the multilayer sample will be obtained after the resonant scattering measurement.

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