Energy Calibration of RBS System Using Mono-Isotopic Metal Films

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1. Introduction

The RBS (Rutherford Backscattering Spectrometry) system was installed in the 1.7 MV tandem accelerator of KOMAC (Korea Multi-purpose Accelerator Complex) in 2017 and user services were started from 2018. As well known, the Rutherford Backscattering Spectrometry (RBS) is a non-destructive method for the surface layer analysis of solids. For the RBS analysis method, the backscattered ion energy is strongly related to the incident ion energy. By using resonance reaction, we can calibrate the incident ion energy. For the RBS spectrum analysis using SIMNRA, we have to know energy calibration curves of its detector system. To calibrate the tandem accelerator energy and to verify the RBS detector system, we conduct energy calibration using mono-isotopic metal films on Si wafers. In this paper, the calibration results are summarized.

2. Methods and Results

2.1 Kinematic Factors

For the energy calibration, we used three kinds of mono-isotopic metal films on Si (100) wafers. The thicknesses of the Al-27, Au-197 and Co-59 were 800, 300, 300 nm. These films were supplied by the KIST (Korea Institute of Science and Technology). The incident He^{2+} ion energy was 3.043 MeV which is the resonance energy for $^{16}O(\alpha,\alpha)$ reaction. From the RBS spectra of these films, we can obtain 4 pairs of energy-channel data.

For the kinematics, the energy E_1 of a backscattered projectile with incident energy E_0 and mass M_1 after scattering is given in the system by

$$E_1 = KE_0 \quad (1)$$

where the kinematic factor K is given by

$$K = \frac{M_1^2}{(M_1+M_2)^2}\left\{\cos\theta \pm \left[\left(\frac{M_2}{M_1}\right)^2 - \sin^2\theta\right]^{1/2}\right\}^2 \quad (2)$$

θ is the scattering angle and M_2 the mass of the target nucleus initially at rest.

From these equations, we calculate the K factor and energies as shown in Table. 1. The scattering angle was 170˚.

Table 1. The kinematic factors.

	K	$E_1=K*E_0$[keV]
O-16	0.3658	1113.191
Al-27	0.5556	1690.733
Co-59	0.7653	2328.870
Au-197	0.9232	2809.292

2.2 Oxygen Resonance Peak

To calibrate the energy of the tandem accelerator, we used the oxygen resonance peak from the Co film. The Oxygen resonance peak energy is 3.043 MeV from literature. So we measured the spectrum data from the Co film sample changing the incident He ion energies. The Fig. 1 shows the changes of oxygen peak intensities according to the He ion beam energy.

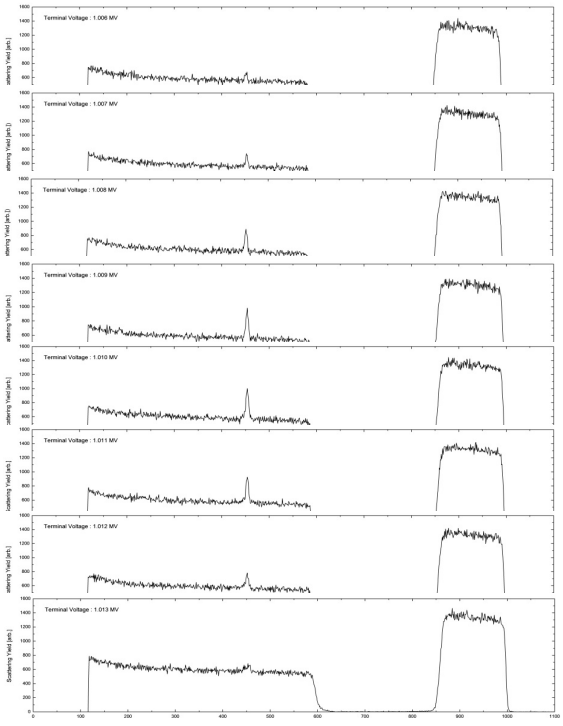

Fig. 1. Oxygen peak intensities according to the He ion beam energies.

The He^{2+} ion beam energy from the alphatross ion source was 23 keV and the terminal voltages are in the range of 1.006 ~ 1.013 MV with the interval 0.001 MV. As shown in Fig. 2, the terminal voltage for the highest peak intensity is shown at the terminal voltage of 1.00979 MV from the fitting results. The difference from the calculated value, 1.00667 MV is 0.00312 MV.

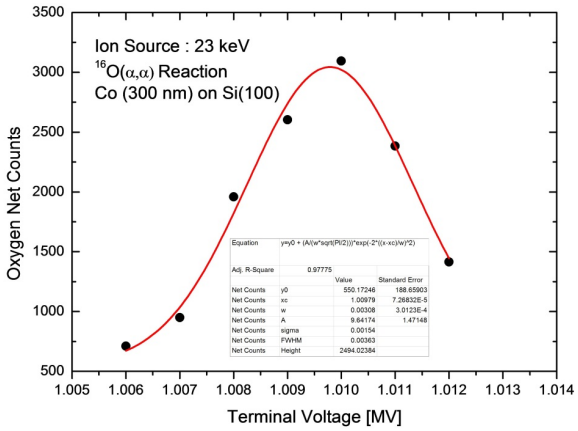

Fig. 2. Excitation curve of $^{16}O(\alpha,\alpha)$ reaction.

2.3 Energy Calibration

With the 3.043 MeV He^{2+} incident ion beam, we measured the backscattered ion energies, and the spectra were shown in Fig. 3. We can found the oxygen resonance peak from Co film.

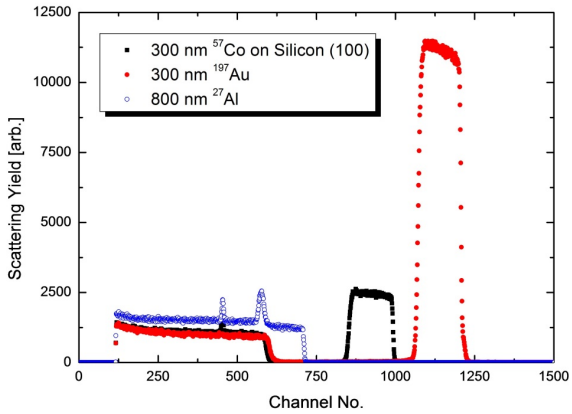

Fig. 3. ^{16}O, ^{197}Au, ^{59}Co and ^{27}Al spectra using 3.043 MeV $^{4}He^{2+}$ beam.

By the least square fitting of the peaks from metal films, we can acquire the energy calibration curves as shown in Fig. 4.

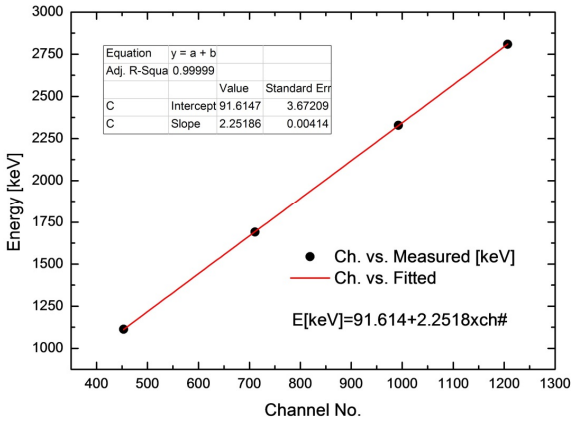

Fig. 4. Energy calibration curve.

3. Conclusions

We performed the energy calibration of the RBS system using three mono-isotopic metal films. As a results, we can find out that the real terminal voltage of the 1.7 MV tandem accelerator of KOMAC is 3 kV greater than displayed. And we can obtain the energy calibration curves used for the spectrum analysis. The offset of the calibration equation is slightly out of range, so, we will check the ADC system and other related parts of the system.

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REFERENCES

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