Composition Profile of Thin Film Target by Rutherford Backscattering Spectrometry

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Introduction

Rutherford backscattering spectrometry (RBS) has been in regular use at IUAC as an ion beam based analytical technique for providing accurate information about the elemental composition near surface of the material. RBS gives pertinent information about composition profile of the target within a few micro meter depth from the surface. This technique is very useful not only for thin films but also for bulk samples. In this paper, the RBS analysis for a self-supported, carbon backed and caped nuclear target samples has been presented.

Some of the advantages of RBS for these samples are as follows. (i) It is a nondestructive technique for precious targets. (ii) This gives accurate estimation of thickness and composition of target film. (iii) Knowing the presence of impurities can help to select best sample and necessary modification can be done during sample preparation. (iv) Samples uniformity can also be verified. (v) The accurate information about the thickness helps in suitable energy selection for experiment [1].

Experimental Details

RBS measurements were performed using 5SDH-1.7MV Tandem accelerator at PARAS (Pelletron Accelerator for RBS-AMS System) at IUAC. The energy of beam used is 2MeV.

The samples are mounted on sample holder on four axis Goniometer perpendicular to the beam direction. A special sample frame of Aluminum having hole in the middle, backed by thick carbon block has been prepared for placing samples. The carbon block absorbs all non-backscattered He^+ ions by which we can avoid backscattered signals from the holder. In the end station chamber (RBS 400 CEA system), is vacuum of the order 10^{-6} Torr was maintained during the experiments. The backscattered He^+ ions are detected at 166^0 by silicon surface barrier detector of solid angel ~ 4 msr, having resolution of 15 keV for 2 MeV He^+ ions. The beam intensity is kept constant at 10 nA and 10-15 μC charge are collected per spot in different position on the same sample. To find thickness of carbon backed layer, samples are flipped and the measurement performed by the same procedure as mentioned above. Data are collection was done using NEC RC43 analytical system. Data recording can be monitored online on screen display with Energy/channel number in x-axis and number of counts or yield in y-axis. Calibration has been performed using Au film on quartz sample. Simulation and analysis is done using RUMP code for RBS [2].

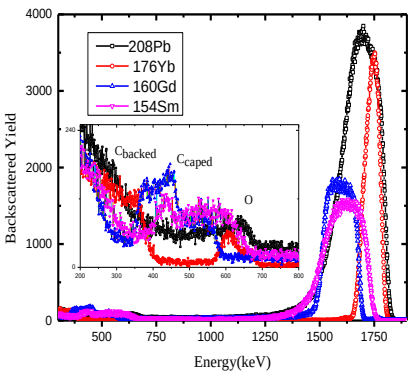

Fig. 1. RBS Spectra of 154Sm, 160Gd,176Yb and 208Pb target sample.

Results and Discussion

The concept of energy loss of energetic ions within material plays a vital role in understanding and analyzing RBS data. Most of the RBS measurements are performed with He^+ or H^+ beam having energy ranging from few keV to few MeV. As the beam passes through first layer it losses a part of its energy before going to next layer and in return path after backscattering it also losses some energy to reach up to the surface. The incident energy at second layer is reduced due to the energy lost in first layer. The He^+ ion range and energy loss in all element and compounds are well estimated and experimentally measured. These values are readily available with code SRIM [3].

The kinematic factor (*K*) is the ratio of He^+ backscattered energy (*E*) to that of He^+ incident energy (E_0). *K* is unique for each element as it depends on atomic mass. In the spectra, the surface edge at higher energy side gives E value. The values of backscattered energy for different element are cited in table 1. In case of carbon backed and caped samples the spectra shows two distinguishable carbon peak with different channel number as He^+ ions losses its energy in both front and back layers, so the incident energy becomes different for concerned layers [4].

The counts or yield depends on the scattering cross section of the element. In the spectra yield height for Pb, O and C are different, as scattering cross section is directly proportional to square of atomic number.

Thickness of the film is calculated by formula,

$$\Delta t = \frac{1}{\Delta E}\left\{K\frac{dE}{dx_{in}} + \frac{1}{|cos\Theta|}\frac{dE}{dx_{out}}\right\} \ldots (1)$$

Where: ΔE is FWHM of energy width in spectra, *K* is kinematic factor, *dE/dx* is energy loss of He^+ ion in element, Θ is backscattered angle. All mathematical equations, kinematic factor, differential cross section, backscattered yield, total integrated counts etc. are discussed in ref [1].

RUMP Simulation code

RUMP - the RBS plotting, analysis and simulation package. This is specifically designed for the analysis and simulation of RBS data. When user fits the experimental data with RUMP simulation code, result can be directly extracted and one can dig out the significant information [5].

Table 1: *K, E,* scattering cross section (σ), and thickness (Δt,in atoms/cm^2) for He^+ ion of 2MeV incident energy.

Element	*K*	*E* (keV)	σ (b/ster)	Δt **x**1e15
Sm	0.899	1798	4.973	150.5
Gd	0.903	1808	5.366	1458
Yb	0.912	1824	6.421	154.8
Pb	0.925	1851	8.705	223.4

Conclusion

5SDH-1.7MV Tandem Pelletron accelerator for RBS facility has been developed and is being used regularly at IUAC. A large number of academic researchers from different universities, institutes and colleges from various parts of country and abroad have been using the facility regularly. It is a compact and versatile facility which is being used for different types of measurements such as RBS, Resonance RBS, and RBS- Channeling for development of better understanding of the compositional profile and quality of the target.

References

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