Rutherford backscattering spectroscopic analysis for thick nuclear targets

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Introduction

The Rutherford backscattering spectroscopy (RBS) technique serves as nondestructive tool for analyse thin and semi thick targets. This measurement directly provide information about elemental confirmation, accurate thickness, composition and impurities near surface of the target. The knowledge of semi thick target are very vital in nuclear spectroscopy and lifetime measurements. The thickness of targets vary from 0.5-few mg/cm^2 on the basis of objective of the measurements. Conventionally, these semi-thick targets are prepared by rolling, thermal evaporation, e-beam evaporation, etc.[1–4]

The present paper describe the RBS measurement of ^{169}Tm target. This information will be used in future analysis of data, specially the lifetime measurements. ^{169}Tm is prepared by cold rolling technique [5] . The thickness of the target is approximately 1.2 mg/cm^2 by weight and area measurement. The exact measurement of target thickness and composition has been confirmed by RBS.

Target preparation

The ^{169}Tm target was rolled using rolling mill at Target laboratory, Inter University Accelerator Centre (IUAC) New Delhi. Stainless Steel (SS) sheet is folded in such a way that we can put target material inside and rolled it properly and also to avoid any unbalanced force on the target material. The slackness of the SS plate can also produce an unwanted strain on the metal foil. The inner surfaces of this SS plate were cleaned by isopropanol, to make it dust-free. This SS plate fed through cylindrical rollers of rolling mill. These rollers exert pressure on the SS sheet from both sides so that there is uniform material stretching. The rolling pressure is increased sequentially so that the material does not get uneven stretching. The whole process is repeated many times to get the desired thickness. Below 8mg/cm^2 thickness, Thulium foil started sticking with the surface of the SS plate. To prevent this, isopropanol, which also acts as lubricant, has been sprayed repeatedly. For the exact estimation of thickness, the target foil is trimmed in such a way that we can measure its area. After reaching the desired thickness, the foil was cleaned using trichloroethylene, acetone, and alcohol. Distilled water is also used to clean the target foil but, we have not used this because Thulium is quite electropositive and reacts slowly with cold water and quite quickly with hot water to form thulium hydroxide.

RBS Characterization

The RBS measurements are performed using NEC make 5SDH-2 tandem accelerator at IUAC. The target is placed on the holder with a carbon block backside. The holder is fixed horizontally to 4 axes motorized goniometer. The vacuum of $\approx$ -10$^-$6 Torr is achieved by a turbo molecular pump backed by a Rotary roughing pump. After the establishment of a vacuum, the Silicon Surface Barrier Detector (SSBD) fixed at 166° backscatter angle biased with 120 V. The calibration is performed, 2 MeV He$^+$ beam is incident on partial roughed Au film on SiO_2. The backscattered spectrum is collected using RC43 software. The known positions of Si and Au 1110 keV and 1840 keV

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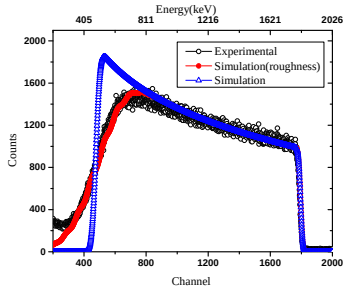

FIG. 1: RBS Spectrum for ^{169}Tm, measured spectra (black), simulated without roughness (red), with roughness (green)

respectively are marked. The current kept 10 nA constant and 5 C charge collected for each position of the sample. The arch structured electron suppressor kept between target and detector without disturbing incoming beam. The voltage of 400 V applied to get rid of the electron current in the charge sensitive SSBD.

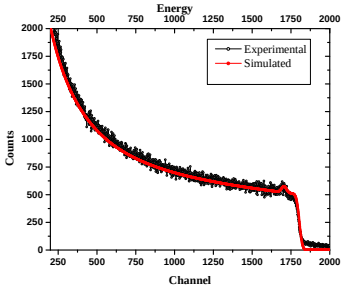

FIG. 2: RBS spectra of Au target measured (red), simulation (blue)

Result and Discussion

The analysis of RBS spectra is done by XRUMP [6] and SIMNRA [7]. For Thick targets which includes tail extended to lower energy region as in the FIG.1. In the spectrum, surface roughness reflects at extending FWHM towards lower energy. The Substrate is the backside of the target where the spectrum roughness reflects till the end of spectrum tail. The RBS analysis formalism is discussed in reference[1]. The kinematic factor (K) for Tm is 0.191 at energy 1820 keV and Indium is 0.8706 at energy 1742 keV confirms respective elements. Au is expected to be at energy 1846 keV but due to loss of He energy in the Indium layer, it appears at 1830 keV.

From the RBS spectra of Tm, the thickness is found to be 1.3 mg/cm^2 . The comparison is also done with and without roughness input in the simulation. The RBS results confirm that the target is pure and the surface is rough is 0.2 mg/cm^2. The estimated thickness of Gold is 5 mg/cm^2 but RBS spectra can probe only up to ≈1.0 mg/cm^2 and no roughness input is given. Additionally, an Indium of 0.03 mg/cm^2 thick also found on Au surface.

Summary

The RBS analysis is more suitable for near-surface studies of thin-film and thickness up to 1 mg/cm^2. This can accurately provide thickness, composition, an indication of impurities, material transformation to oxides. The target beyond this thick doesn't yield any significant information. The thickness of Tm estimated from weight/area measurement and RBS are in good agreement.

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