Application of RBS, SEM, and EDS Characterization for Nuclear Physics Experimental targets at IUAC

G R Umapathy[1],* K Deeksha[1], R Sharma[1], Pankaj Kumar[1], S Ojha[1], S Gargari[1], A Banerjee[2], Kavita Rani[3], S R Abhilash[1] D Kabiraj[1] S Chopra[1] and D Kanjilal[1]
[1]*Inter University Accelerator Centre(IUAC), Aruna Asaf Ali Marg, New Delhi - 110067, INDIA*
[2]*Department of Physics and Astrophysics, University of Delhi –110007, INDIA*
[3]*Department of Physics, Panjab University, Chandigarh ,160014, INDIA*
** email: umagrphysics@gmail.com*

Introduction

Target for nuclear physics experiments are crucial to the successful experiment and analysis. The most important is to confirm elemental purity, composition, thickness, homogeneity etc. A good target for nuclear physics experiment has to be stable and provide good statistics during the experiment. The preparation of thin free standing or supported target for studying nuclear reaction, structure, spectroscopic studies is more challenging as compared to the normal thin film deposition on substrate. The essential requirements for nuclear target are elemental and isotopic purity, accurate thickness and homogeneity, good tensile strength and stability to ion irradiation. The ultra-thin films nm range cannot be prepared free standing and they are backed with low Z material such as Carbon or high Z material like Al , Au, Th depending on the experimental requirement. The Sandwiched type of target are capped to prevent oxidation, surface contamination, avoid direct contact to skin etc. The target thickness and backing thickness also influence the resolution of the measured spectrum in the main experiment. The free standing target of Er, preparation by cold rolling technique, thin sandwiched target of Er and Sm with carbon backing/capping are prepared either via resistive heating or e-gun evaporation or in combination at target preparation lab, IUAC [1]. The analysis of target by RBS , SEM and EDS will be discussed.

Rutherford Backscattering Technique

The Rutherford backscattering Spectroscopy is the best technique for near surface analysis as it gives accurate information of film such as element confirmation, thickness, composition, uniformity and purity. A known energy of He^+ beam is bombarded to the target and back scattered ion which have lost partial energy on kinematic collision and energy loss process in target atoms are detected in SSBD at backscattered angle. The details of RBS measurements at IUAC described in Ref [2].

The advantages of this technique for analyzing nuclear targets are (1) It is a nondestructive technique for precious targets. (2)Elemental confirmation. (3)This gives accurate estimation of thickness and composition of target film. (4)Presence of impurities are detected. (5)Samples uniformity can also be verified. The target elements are usually are of higher mass due to which any impurity of lower mass or backing/capping element cannot be identified via RBS.

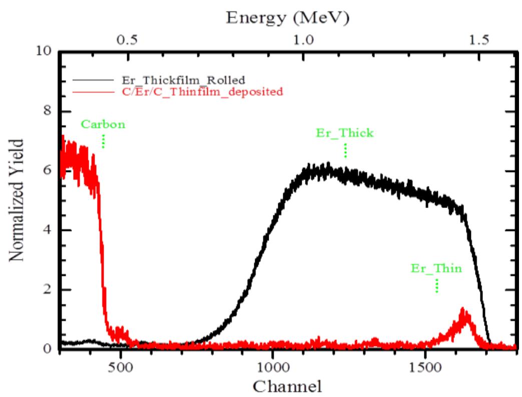

Fig. 1 RBS spectra of Er Thick (black) and Er Thin sandwiched between C.

EDS and SEM

The surface morphology of nuclear targets are studied via Scanning Electron Microscope (SEM). The Energy Dispersive X-ray Spectroscopy (EDS) attachment allow to identify particular elements and their relative proportions of atomic percentage. The incoming accelerated electrons interact with materials results in emission of characteristic X-rays. The information is recorded via Silicon Drift Detector. The SEM/EDS measurements are carried using JOEL's FESEM (model 7610F) attached with EDAX's Octane plus EDS detector [3].

Result and Discussion

Er (rolled), Er with C backing and capping via resistive heating and Sm with C capping via e-beam evaporation were analyzed. The Results of RBS and EDS confirm presence of expected target element, carbon and Oxygen. The rolled Er target and Er with capping and backing are analyzed and its RBS spectra is shown in fig. 1[5]. The targets prepared by resistive heating and e-gun evaporation technique or in combination are stack of sandwiched layers evaporated at high/medium vacuum. The oxygen incorporation with the target material at low/medium vacuum deposition or sample oxidation on exposure to atmosphere is detected in most of the samples.

Table 1: Target type, thickness, composition, other element detected

Target Type	Target	Thickness *$\mu g/cm^2$	Impurities
Rolled	Er_1	814.5	C, O
Main target by e-beam evaporation and capping by Restive heating	C/Er/C	Capping -12 Er -36.2 Backing-34	Nil
	Sm/C	Capping -12 Target -189	O, Ta

The RBS and EDS spectra shows presence of oxygen in carbon sandwiched Sm target. Deposition via electron beam evaporation, introduces contamination from the crucible (of Cu or Ta) in which the element is kept which can be observed in the EDS spectra of Sm target as shown in Fig 2. With RBS analysis, copper couldn't be detected as its mass is lower compared to that of Sm which can be detected by EDS measurements. The electron beam evaporation method was found to be the most suited method for preparing Er and Sm targets. Resistive heating method was employed for backing/capping of target by carbon. The information is presented in table 1. The Er quantity in switched target is too low to be used in nuclear physics experiment.

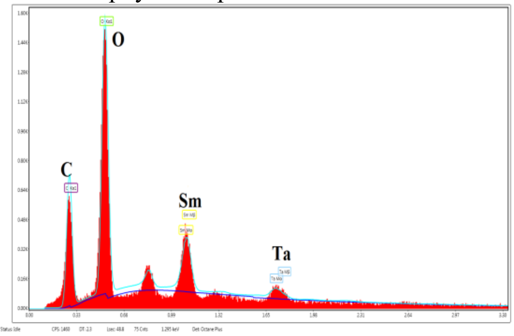

Fig. 2 EDS spectra of Sm target with O and Ta

Conclusion

The target preparation and characterization using RBS, EDS give precise knowledge of the prepared target and feedback regarding suitable methodology of stable target. The preparation of Er target is quite complicated and reliable information of thickness is essential for main experiments. The Sm get oxidized very fast and eventually deteriorates and becomes fragile. Suitable capping is required to prepare stable target.

Acknowledgment

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