Nuclear Instruments and Methods in Physics Research B 359 (2015) 78–84

Contents lists available at ScienceDirect

Nuclear Instruments and Methods in Physics Research B

journal homepage: www.elsevier.com/locate/nimb

dE/dx and range of α-radiations in Al, Ti and Ni metallic foils

P.K. Diwan *, Sunil Kumar

Department of Applied Science, UIET, Kurukshetra University, Kurukshetra 136 119, India

ARTICLE INFO

Article history:
Received 26 June 2015
Received in revised form 17 July 2015
Accepted 17 July 2015

Keywords:
dE/dx
Range
α-Radiations
Metallic foils

ABSTRACT

dE/dx and range of α-radiations in Al, Ti and Ni metallic foils have been measured using silicon surface barrier detector. These measured values have been compared with corresponding predicted values based on most extensively used formulations viz. Grande and Schiwietz (CasP), Northcliffe and Schilling, Benton and Henke, ICRU-49 report (ASTAR) and Ziegler et al. (SRIM). The aim of this comparison is to identify the formulation that shows good agreement with the presently measured values.

1. Introduction

In material science, α-radiations play a vital role to determine thickness, depth profiling and elemental composition of thin target materials [1–5]. The effective use of radiations in these applications requires the accurate knowledge of energy loss per unit path length (dE/dx) and mean path travelled by radiations before losing their entire energy (range), in a desired material. This indicates that the precise measurement of dE/dx and range of α-radiations are highly essential. However, it is practically impossible to measure these values of α-radiations at various energies and in different materials because of infinite permutations. Therefore, the only alternate is to exploit the most suitable theoretical formulation for dE/dx and range calculations and this can be achieved through comparison with the measured values.

In the present study, we measured dE/dx and range of α-radiations in Al, Ti, and Ni metallic foils. These metallic foils are selected because these cover a range of atomic number with Z = 13–28. Further, these materials are highly important in various applications. For example, Al foils are used in thermal insulation, electrical coils, capacitors, transformers, decorative products, etc. [6]; Ti as a material is useful for contact formation in Metal–Oxides–Semiconductor (MOS) devices in micro-electronics [7,8]; Ni foils are useful for constructing high strength windows for use with high-current ion beams [9]. The measured dE/dx and range values in these materials are also compared with the computed values based on the most commonly used theoretical/semi-empirical formulations (Grande and Schiwietz (CasP) [10–13], Northcliffe and Schilling [14], Benton and Henke [15], ICRU-49 report (ASTAR) [16–17] and Ziegler et al. (SRIM) [18–19] in order to identify the best suitable formulation with the presently measured values.

2. Experimental details

For present measurements, Al, Ti and Ni metallic foils were procured from STREM Chemical, USA. These metallic foils were rolled with a hardened roller machine by inserting different pressure and consequently thinner metallic foils were obtained. Thicknesses of these thinner foils vary from ~0.77 mg/cm^2 to 7.23 mg/cm^2 as measured through gravimetric method. In order to ascertain the thicknesses of the rolled foils, in some cases, four/five pieces were cut from same rolled foil and thicknesses were measured. The statistical error in thickness measurements was hardly 2%. Gravimetric method only gives the average thicknesses of the metallic foils and does not provide any information regarding the microscopic non-uniformities in thickness measurements. This information does not affect much the present measurements. Further, in order to reduce the contribution of non-uniformity (if any), we measured the thickness of that area, which is mounted in the front of the detector. In addition, upon exposure to air, metal surface may get oxidized. But earlier studies indicate that the maximum oxygen content in the considered metallic foils is hardly 2.6% by weight [20–22], therefore it should not significantly effect the present measurements.

* Corresponding author.
E-mail address: diwanpk74@gmail.com (P.K. Diwan).

http://dx.doi.org/10.1016/j.nimb.2015.07.093
0168-583X/

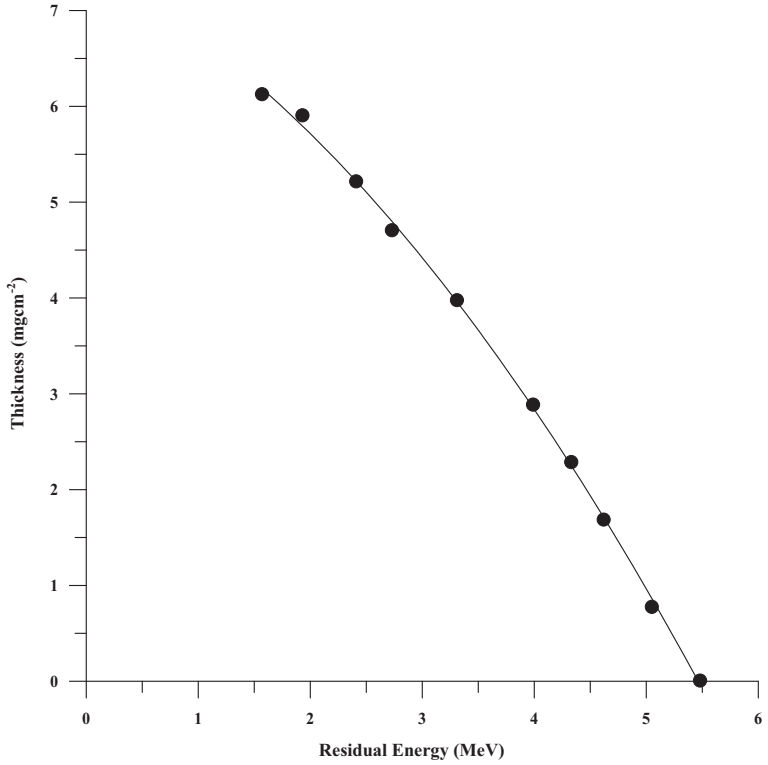

Fig. 1. Least square fit between thicknesses and residual energies of α-radiations in Ti metal.

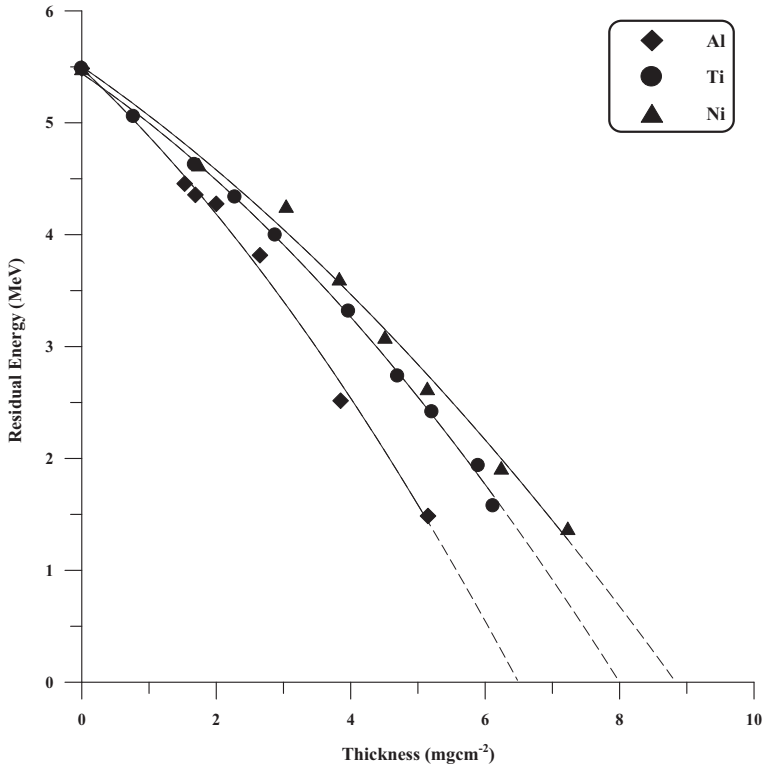

Fig. 2. Extrapolated fitted curve between residual energies and thicknesses in Al, Ti and Ni metals.

In order to measure dE/dx and range in these metallic foils of 5.486 MeV α-radiations, ^{241}Am source was used. These α-radiations were collimated and allowed to pass through different thicknesses of the metallic foils and then energy of transmitted α-particles were measured using a silicon surface barrier detector (SSBD) and corresponding energy spectra were stored in an online