International Journal of Pure and Applied Physics.
ISSN 0973-1776 Volume 13, Number 2 (2017), pp. 259-263
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Thickness Measurement of Thin Film by PIXE

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Abstract

To carry out Nuclear reaction at an accelerator facility, one very essential requirement is the proper choice of a target,target thickness and its fabrication. Many technique has been developed for thickness measurement of thin film like mass evaporated and mass added, RBS, XRF, X-ray diffraction technique, but one very sensitive, fast and accurate technique is PIXE (Particle Induced X-ray emission technique). In this accelerator based technique, Proton beam of energy 2.7 MeV was used for thickness measurement of Au and Ni thin metallic target. Thickness was calculated by using GUPIX software package and X-ray intensity ratio (K_β/K_α) of Ni has been compared with theoretically (ECPSSR) calculated.

Keywords: PIXE, XRF, RBS, X-ray Cross- section, ECPSSR, GUPIX.

INTRODUCTION

Particle Induce X-ray Emission (PIXE) is an efficient and powerful analytical tool for major, minor, and traces elemental analysis in a variety of fields like biology, environment, medicine, archaeology, and forensic science [1]. This technique also used for analyzing the composition of rocks, metals, ceramics, and other materials. PIXE is one the very favorable techniques because it is non-destructive, and very fast. PIXE technique has several other advantages, such as, requirement of analysis of very low concentration of trace elements, quantity of the sample is very limited etc. In this technique ion beam is used to ionized the inner shell of target atoms of the sample and then vacancy is filled by upper-shell's electrons, which leads to emission of a characteristic X-rays. PIXE thickness measurement of Au film play very important role for range verification in eye proton therapy [2].

METHOD:

Energy and intensity of these X- rays are used to identify element and its concentration determined by C_z [1].

$$C_z = \frac{Y_m}{[Y_t\{HQ\varepsilon T\}]}$$

Where Y_m and Y_t are measured and theoretical X-ray yield respectively q is the real charge collected by faraday cup, ε is the intrinsic efficiency of the detector and T is the transmission of X-ray through any medium present between source and detector.

H value is the instrumental constant which is product of the geometric solid angle of the X-ray detector and charge correction factor. It was determined by analyzed a standard reference material at PIXE facility Panjab University, Chandigarh (India).In case of thin targets, the line intensity for a peak is proportional to the X-ray production cross section ,for this we calculated by using theoretical(ECPSSR) code[8] and compared with experimental measured for Ni target. ECPSSR theoretical X-ray production cross section also used for concentration determination, this theory is a modified Plane wave Born approximation (PWBA) with energy-loss Coulomb-repulsion perturbed-stationary-state relativistic it become (ECPSSR) theoretical model[4].which is known as ECPSSR theory, the details of theoretical model describe in details elsewhere [4-7] ECPSSR theory includes various physical processes, such as, projectile energy loss, Coulomb deflection of the projectile, perturbation of electron's stationary state (polarization and binding), as well as relativistic effect.

EXPERIMENTAL DETAILS:

The measurements were carried out using the Cyclotron facility available with PIXE setup at the Department of Physics, Panjab University Chandigarh (India). A collimated proton beam of energy 2.7 MeV having 5-9 nA beam current was used for these measurements. The X-ray yield was measured using a planar HPGe detector with Be window of thickness of 25μm having energy resolution of 160 eV at 5.9 keV. The efficiency and energy calibration were carried out using standard radioactive sources. The X-ray data was collected using MCA and off-line data analysis has been carried out by using GUPIX] software [3] installed at PIXE facility. Ni X-ray intensity were analyzed by Candle programme.

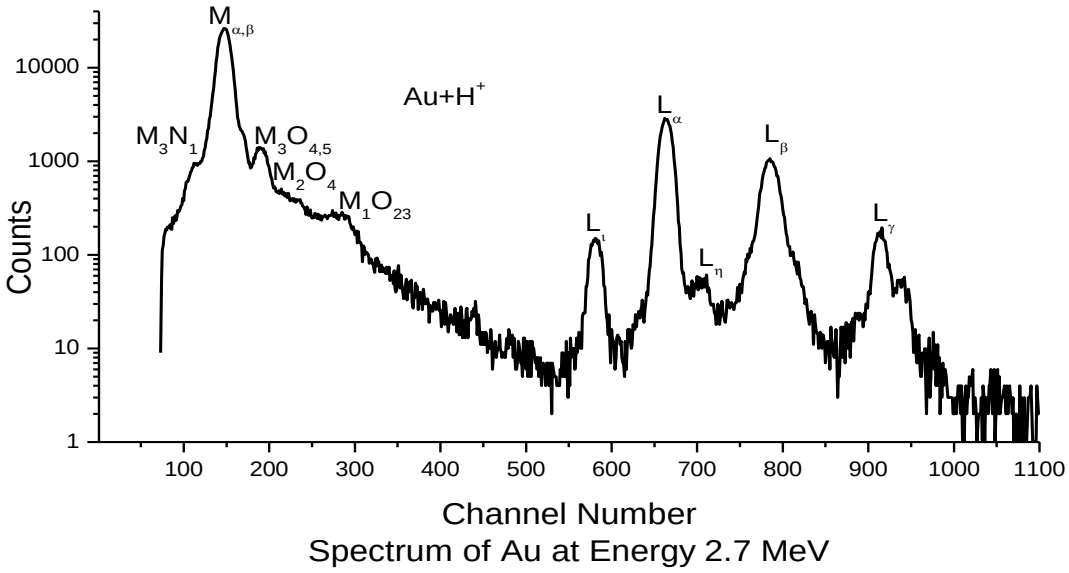

Figure 1: PIXE of Au by Proton, indicating peaks of L-shell and M-shell X-ray.

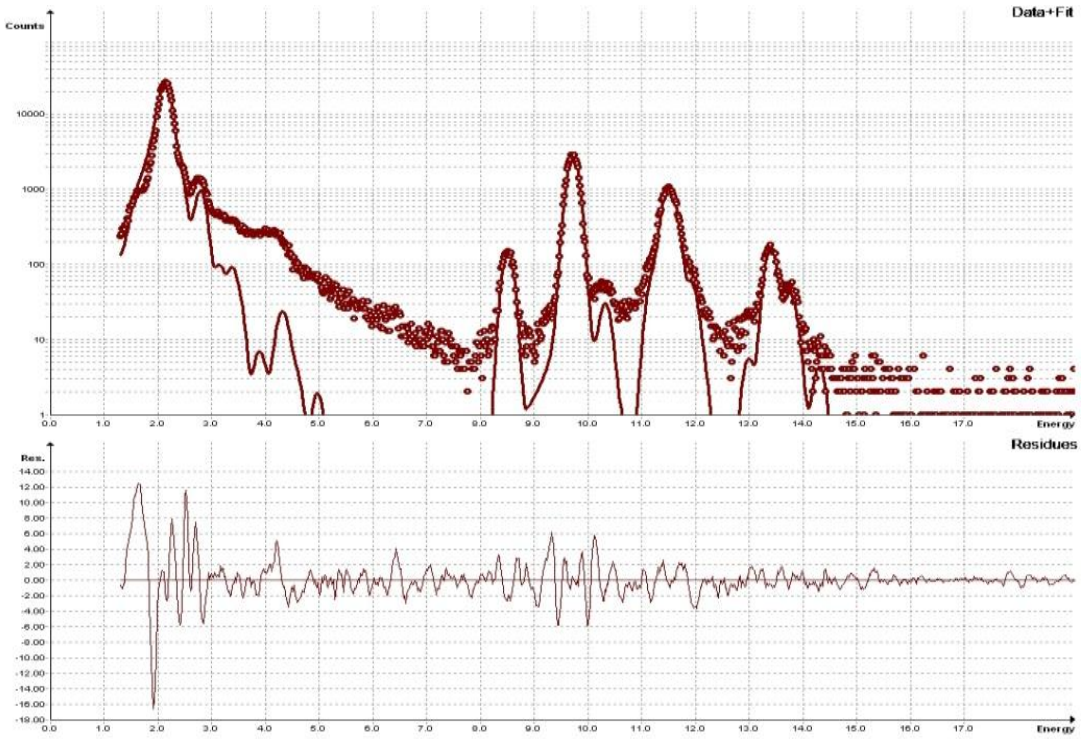

Figure 2: PIXE peaks, indicating fitted residuals by GUPIX

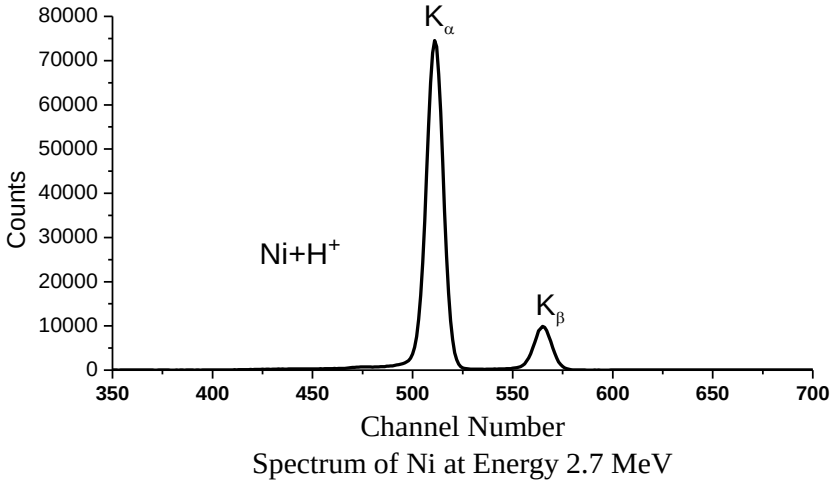

Figure 3: PIXE peaks of Ni by Proton

RESULTS

Thickness of Au thin film, 304.15**μ**g/cm^2 or 0.157 **μ**m and thickness of Ni, 220.9115**μ**g/cm^2 or 0.248 **μ**m has been measured by using PIXE facility and GUPIX software package .PIXE measurements performed on Au and Ni thin film, fitted residuals indicating 'goodness of fit with χ^2 =5.149 . X-ray intensity ratio (K_β/K_α) of Ni has been compared with ECPSSR theoretical model; it has been found good agreement between theory and experiment. Intensity ratio was experimentally 0.1321, and theoretically 0.1227.

CONCLUSION

A procedure of thickness measurement by Proton beam exposure, and spectrum analysis has been set up capable of detecting very fast and accurately measurement. Au thickness measurement play important role in Range verification for eye proton therapy based on proton-induced x-ray emissions from implanted metal markers [2].

ACKNOWLEDGEMENT

The author is thankful to PIXE facility In-charge Dr. Ashok Kumar and supporting staff of PIXE facility Panjab University Chandigarh (India). The first author is also thankful to UGC and Banaras Hindu University for the research fellowship provided under Ph.D. registration No.(PHY/RES/RET Qualified-2013/2013-2014/923 dated 20.11.2013).

REFERENCES:

[1] S.A.E. Johanson, J.L. Campbell PIXE,A Novel Technique for Elemental Analysis, John Wiley &Sons,1988.
[2] Vanessa La Rosa et al, IOP Phys. Med. Biol. **59** (2014) 2623–2638.
[3] J.A. Maxwell, W.J. Teesdale, J.L. Campbell,NIM B 95(1995) 407
[4] G. Lapicki et al , Phys, (1981)1717
[5] W. Brandt et al , Phys, Rev 23 (1981)975.
[6] Campbell J.L. (2003-2009). Atomic Data and Nuclear Data Tables, 85, 291-315.
[7] Krause M.O. 1979.. J.Phys. Chem. Ref. Data, 8 (2), 307-327.
[8] Vladimir Horvat computer Physics communication 180(2009) 995-1003