SURFACE ANALYSIS OF THICK TARGETS BY NUCLEAR TECHNIQUES

José A. R. Pacheco de Carvalho[1,2], Cláudia F. F. P. Ribeiro Pacheco[1], A. D. Reis[1,2]

[1] APTEL (Applied Physics and Telecommunications) Research Group, [2] Dept. de Física,
Universidade da Beira Interior, 6201-001 Covilhã, Portugal
Contact email: pacheco@ubi.pt

Various complementary techniques have been developed for surface analysis of materials. Nuclear techniques, using low energy MeV ion beams, give absolute values of concentrations of isotopes and elements for a few microns close to the surface. Their main applications have been given in areas such as scientific, technologic, industry, arts, archaeology and medicine [1-7]. Tracing of isotopes with high sensitivities is possible by nuclear reactions.The energy analysis method is used for ion-ion reactions. At a suitable bombarding energy, an energy spectrum is recorded of ions from reaction events occurring at several depths in the target. Such spectra are computer predicted and compared to data, giving target composition and concentration profile information [4-7]. Elastic scattering is a particular and important case of nuclear reactions. A computer program has been developed in this context, mainly for flat targets [4-6]. The non-flat target case arises as an extension. Depth profiling of light nuclei e.g. ^{12}C is made by the $^{12}C(d,p_0)^{13}C$ reaction in a thick flat target of extremely high purity pyrolytic graphite. Experimental details are available [4]. The simulations used published nuclear data, namely for differential cross section and stopping power. A very good computed fit was reached to spectral along a high depth of X_1>12.5 μm. The result would be difficult to obtain by other techniques, showing nuclear reaction analysis as a highly powerful analytical tool for non-destructive surface analysis of materials.
Elastic scattering of α particles was used for analysis. Published nuclear data were used in the simulations. Rutherford and resonant scattering differential cross section were used when applicable. A very good computed fit was obtained to the α spectrum obtained from a thick flat target containing a compound of Al and O. Elastic scattering has shown to be an additional strong non-destructive analytical tool for surface analysis.

Acknowledgements
Work with support from University of Beira Interior and FCT (Fundação para a Ciência e a Tecnologia)/PEst-OE/FIS/UI0524/2014 (Projecto Estratégico-UI524-2014).

References
[1] Wang, Y., Nastasi, M., (eds.) (2009), Handbook of Modern Ion Beam Materials Analysis (2nd ed.). Pittsburgh, PA: Materials Research Society.
[2] Amsel, G., Battistig, G. (2005). Nucl. Instr. and Meth. B, 240 (1), 1-12.
[3] Calvert, J. M., Derry, D. J., Lees, D. G. (1974). J. Phys. D: Appl. Phys., 7, 940-953.
[4] Pacheco de Carvalho, J. A. R., Reis, A. D. (2008). Nucl. Instr. and Meth. B, 266 (10), 2263-2267.
[5] Pacheco de Carvalho, J. A. R., Reis, A. D. (2008). Bol. Soc. Esp. Ceram. V., 47 (4), 252-257.
[6] Pacheco de Carvalho, J. A. R., Ribeiro Pacheco, C.F.F.P., Reis, A. D. (2011). Nucl. Instr. and Meth. B, 269 (24), 3054-3056.
[7] Barradas, N.P., et al. (2007). Nucl. Instr. and Meth. B, 262 (2), 281-303.