Thin target PIXE calibration using thick target yields

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The PIXE (Particle Induced X-ray Emission) method is an analytical technique mainly used to determine the elemental composition of small samples and thin films. It allows the detection and quantification of elements with Z>12, with detection limits in bulk matter of the order of μg/g.

Currently, the quantitative calibration of the SP-PIXE installed at the Laboratory for Ion Beam Analysis of Materials (LAMFI-USP) is done by analyzing a set of ~20 thin film evaporated standards (Micromatter Co.), with thicknesses of about 40μg/cm^2. A semi-empirical thin-film yield curve is calculated to fit simultaneously the K and L sensitivity curves using a reliable physical model that includes all experimental parameters. This approach seems to be better and physically more reliable than the usual polynomial fit (or single element calibration), since it reveals systematic deviations from theory that can be further investigated. For the analysis of thick samples, we developed a special computer program, *Clara*, that calculates F_i, a parameter that relates the thin film sensitivity yield, r_i to the thick target sensitivity yield, R_i by calculating a relative correction to the thin target cross section:

$$F_i = \int_{E_o}^{E} \frac{\sigma_{xi}(E')\, e^{\frac{-\mu_i \cos\alpha}{\rho \cos\theta}\int_{Eo}^{E'} \frac{dE''}{S(E')}}}{\sigma_{xi}(E_0) S(E')} \quad (1) \qquad N_x = r_i Q \tau \quad (2) \qquad R_i = F_i r_i \quad (3) \qquad N_x = R_i Q \frac{\rho_i}{\rho} \quad (4)$$

In equations (1-4), N_x is the number of X-rays of element *i*, α and θ are the in and out angles measured to the sample normal, σ_{xi} is the X-ray production cross section, *S(E)* is the stopping power, ρ_i and ρ are the elemental and total mass densities of the sample, τ is the thin film thickness and *E* is the final beam energy, where eventually *E = 0*. *Clara* was originally developed to analyze unknown powdered samples diluted 1:10 in Boric acid, were the light elements matrix could be approximated to pure Boric acid with good accuracy [1]. This approach, where the thick target yield is calculated by applying a relative correction to the experimental thin target yields, turned out to work well for several other thick targets where the light element matrix is previously known.

This study investigates the feasibility to extract the thin target sensitivity curve by analyzing single-element thick samples and inverting the scheme previously described. This procedure has the advantage of eliminating the need for the thickness of the thin film standards, thus providing an absolute and unbiased estimate of the thin film PIXE yields, and eliminating one of the experimental sources of error in quantitative PIXE calibration. As a counter back, this procedure needs a precise thick target beam charge collection measurement and an accurate control and correction of detector death times. Results for Al, Ti, Fe, and Cu, with beam energies around 2MeV indicate the validity of the proposed method.

[1] Aburaya et. al. NIM B**249 (**2006).