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Nuclear Reaction Analysis of Materials using MeV Ion Beams

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A wide range of surface analysis techniques has been developed, involving e.g. ion, electron and photon beams interacting with a solid target. The techniques are, generally, complementary and provide target information for depths near the surface. Nuclear techniques, which are non-destructive, provide for analysis over a few microns close to the surface giving absolute values of concentrations of isotopes and elements. Their main applications have been given in areas such as scientific, technologic, industry, arts, archaeology and medicine, using MeV ion beams [1-7]. Tracing of isotopes with high sensitivities is possible by nuclear reactions. We use elastic scattering of light low energy ions and the energy analysis method. At a suitably chosen energy of the incident ion beam, an energy spectrum is acquired of ions from elastic scattering events, coming from several depths in the target. Such spectra are computer simulated and compared to experimental 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 situation arises as an extension.
Ion-ion nuclear reactions were used for analysis. The simulations used published nuclear data, namely for differential cross section and stopping power. Very good computed fits were reached to spectral data obtained for two main targets. T1 was a thick flat target of extremely high purity pyrolitic graphite. It was analysed through the $^{12}C(d,p_0)^{13}C$ reaction at E_d=1.40 MeV and $\Theta_L=165^o$, permitting to find a ^{12}C step concentration profile along a depth of X_1= 10 µm. T2, obtained by high temperature oxidation of austenitic steel in C $^{18}O_2$ gas, had a reasonably flat oxide. A uniform concentration profile of ^{18}O was expected along 4.2 µm. It was analysed through the $^{18}O(p,\alpha_0)^{15}N$ reaction at E_p=1.78 MeV and $\Theta_L=165^o$, permitting to find a uniform concentration profile of ^{18}O with X_1=4.5 µm. Nuclear reaction analysis, as a nuclear technique, has shown to be a very powerful non-destructive surface analysis technique. The results which were obtained would be difficult to reach by other techniques.

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