CONCENTRATION PROFILE MEASUREMENTS USING MULTIPLY RESONANT NUCLEAR REACTIONS

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The concentration profile of an element, admixed with the uniform sample in surface layers can be conveniently measured, if the yield curve of multiply resonant nuclear reactions, as (p,γ) or $(p,\alpha\gamma)$ is properly analysed. The integral yield of nuclear reaction having multiply resonant cross section $\sigma = \sum_i \sigma_i(\Gamma_i^2/4)/((E'-E_i)+\Gamma_i^2/4)$ can be conveniently written as

$$Y(E) = \sum_i \frac{n_F(x_i)\ \rho_i \Gamma_i}{2(dE/dx)_i}\, g_i$$

E being proton energy at the surface, n_F the number density of investigated element, $(dE/dx)_i$ the stopping power of the target at resonant energy E_i and

$$g_i(E,E_i) = \operatorname{arctg}\left[2(E-E_i)/\Gamma_i - \operatorname{arctg} 2(E-E_i-\eta)/\Gamma_i\right],$$

where η is the energy depth of the target.

Comparing the yield Y(E) of investigated sample with the yield $Y_o(E)$ of homogenous calibration target, relative density of the measured element in the target ρ_F to the relative density of the same element in standard ρ_{oF} is

$$\frac{\rho_F}{\rho_{oF}} = \frac{(dE/\rho dx).Y(E)}{(dE/\rho dx)_o . Y(E)_o} \cdot \frac{1}{f} \qquad (1)$$

$f = 1 + \sum(k_i - 1)r_i g_i / \sum r_i g_i \quad ; \quad k_i = n_F(x_i)/n_F(x_1)$ and

$r_i = \sigma_i \Gamma_i (dE/\rho dx)_{o1} / \sigma_1 \Gamma_1 (dE/\rho dx)_{oi}$

Iterative procedure is used to evaluate the relative density ρ_F, using eq. (1).

This method has been succesfully used to measure the fluorine density distribution in 12 μm thick surface layers of tooth enamel with the depth resolution 0,1 μm at the surface.