Application of Conversion Electron Mössbauer Spectroscopy to Surface Studies

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The majority of Mössbauer spectroscopic experiments are performed in a transmission geometry and measure the resonant absorption of a thin absorber. In this mode, data relating to the bulk properties of solids may be obtained.

However, there has been a significant interest in the past few years in backscattering techniques, mainly based on the detection of conversion electrons emitted after resonant events [1,2]. Because these conversion electrons are attenuated rapidly in matter, only those electrons produced in regions close to the surface can escape and the resulting Mössbauer spectrum is weighted towards the surface regions of the absorber. Thus, Conversion Electron Mössbauer Spectroscopy (CEMS) is useful for the analysis of the surface properties of the sample.

Two basic types of CEMS experiments may be performed. The first of these involves the detection of the total flux of backscattered electrons (Integral CEMS), while in the other type, the flux of scattered electrons is energy-resolved and Mössbauer spectra are accumulated using selected bands of electron energy. The latter technique allows the surface regions of solid to be probed as a function of depth (Depth-selective CEMS, DCEMS).

Comprehensive theoretical studies on the intensity and energy distribution of scattered electrons were made using Monte Carlo methods by Liljequist, et al. [3,4].

The ability of DCEMS to probe the surface regions of solids of small surface area in situ (in a non-destructive manner) has made the method particularly suitable for the examination of technical problems such as corrosion [5,6], surface treatment [7] and phase changes [8]. Keune and Sette Camara [5] have studied the oxidation of iron foils at high temperature, and fully demonstrated the ability of this technique to identify new phases formed at surfaces. A very thin surface layer of α-Fe_2O_3, an intermediate layer of Fe_3O_4, followed by a thick layer of FeO were all identified as oxidation products.

Recently, the application of CEMS to rather diverse iron-containing materials has been expanding. Some examples include studies on solid phase reactions [9], thin films [10], single crystals [11], minerals [12] and hydrogen storage compounds (e.g., FeTi [13,14]).

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