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Review

Modeling of elastic and inelastic electron backscattering from surfaces

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Abstract

Reliable theoretical models describing the phenomenon of electron backscattering from surfaces, elastic and inelastic, are needed in analytical applications of electron spectroscopies. Quantitative Auger electron spectroscopy (AES) requires knowledge of a parameter that describes influence of the backscattered current on the monitored signal intensity. This effect is accounted for by the so-called backscattering factor. In scanning Auger electron microscopy (SAM), we are interested in the decrease of the lateral resolution due to radial distribution of the Auger electrons emitted by the backscattered electrons. The theoretical tools are needed to evaluate the line-scans obtained for a non-uniform surface.

In the above problems, calculations are usually based on the Monte Carlo simulations schemes, in which we need different parameters characterizing the interactions of electrons in the solid: elastic and inelastic scattering cross sections, energy dependence of the inelastic mean free path, ionization cross sections, etc. Reliability of the quantitative analysis depends on the accuracy of these parameters. Recent advances in this field are briefly reviewed. Particular stress is put on the determination of the elastic scattering cross sections. There is a growing interest in analytical methods based on the effect of elastic electron backscattering. They are presently known under the acronym EPES (Elastic Peak Electron Spectroscopy). An important application of this technique is the determination of the inelastic mean free path from the measured probability of elastic backscattering.

Keywords: Monte Carlo simulations; Electron–solid interactions; Electron elastic scattering cross sections; Electron stopping power

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1. Introduction

The analytical tools that can be conveniently used for studies of solid surfaces frequently involve the excitation of the surface region with a beam of monoenergetic electrons. An example of such technique is Auger electron spectroscopy in which the Auger electrons are ejected from the solid after ionization of atoms in the surface region. In modern instruments, energy of the primary beam reaches 25 keV, and the diameter of the beam may be decreased down to 10 nm. In electron probe microanalysis, we monitor the intensity of characteristic X-ray radiation due to electron bombardment. The upper energy limit for the electron beam reaches then 30 keV. The problem of electron transport is also very important in techniques in which the surface is scanned by the electron beam, e.g. scanning Auger microscopy (SAM) and scanning electron microscopy (SEM).

Quantification of these techniques is founded on reliable theoretical models describing the trajectories of electrons in the solid. We need to know the relation between the surface composition and the monitored signal intensity. Due to the importance of quantitative surface analysis, much material has been published on the theoretical and experimental issues associated with this problem [1,2]. The formalism used in quantification of electron spectroscopies stems from a possibly accurate description of electron transport in the solid. In the present review, recent advances in the relevant theoretical models are outlined.

We consider here the theoretical aspects of electron backscattering from surfaces. Measurements of elastic electron backscattering probability from surfaces are performed in several important analytical applications; they were addressed in reviews published in this journal [3,4]. These applications are founded on a reliable theoretical model making possible calculations of elastic backscattering probability. A number of models were proposed for such calculations [5,6]. The Monte Carlo approach seems to be presently the most reliable and accurate. Consequently, it is frequently used as a reference for evaluating other theoretical models [4,6].