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Retrieval of the reflection coefficient in spin-polarized neutron specular reflectometry

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Abstract

A method is proposed which allows a complete determination of the complex reflection coefficient for any free unknown real potential (i.e., in the case where there is no effective absorption). It exploits the interference of the spin components of a polarized neutron beam in the presence of a magnetic reference layer mediated between substrate and sample. Following the recent investigations, the method requires polarization analysis of the reflected beam instead of reflectivity analysis. However, our method is based on the transfer matrix formalism. In this method we use the relations between the polarization and the reflectivity of the reflected beam and the transfer matrix elements for the known and unknown samples. Using these relations we show that instead of fully polarization measurement, some suitable choice of polarization and reflectivity measurements can be used to determine the reflection coefficient. The method is supplemented with a schematic example.

1. Introduction

Specular reflectivity of cold and ultracold neutrons can provide important information about physical and chemical phenomena occurring at surfaces and interfaces of condensed matter [1–4]. Hence, the use of such neutron reflection to study thin films and interfaces has increased dramatically. In neutron reflection, the interaction of neutrons with the film's atomic constituents is characterized by a continuous scattering length density (SLD) function which is a number-density-weighted microscopic average of known isotope-specific constants, the scattering lengths. So the SLD can determine the coherent elastic scattering behaviour of neutrons by the microstructure of a film [5].

The major aim of neutron specular reflectometry is to reveal the in-plane average of the SLD depth profile in the direction normal to the surface of materials in thin film geometries [2]. The SLD depth profile of a sample can be directly converted to the chemical profile of the sample [6].

The SLD depth profile determines the specular reflection from a film. So it can be obtained from measurements of the reflectivity, $R(q)$. The reflectivity is defined as the number of

