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Application of polarized neutron in determination of the phase in neutron reflectometry

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Abstract

In order to uniquely determine the scattering length density profile from measured reflectivity of specularly reflected neutrons from a film, the phase of complex reflection coefficient is needed. It has been shown that the phase can be determined by using three reference layers of finite thicknesses. However, this can be done by using one magnetic layer which can have three different scattering length densities corresponding to up, down, and non-magnetization. Moreover, in this case, polarization of reflected beam can be used in determination of the phase. In this paper it is shown that by using the transfer matrix method, it is possible to determine the complex reflection coefficient for any unknown real scattering length density profiles in situations in which a magnetic reference layer is mediated between the substrate and unknown sample. This method is based upon relations between the polarization of the reflected beam and the transfer matrix elements for the unknown sample. Thus, in this manner, only by polarization measurements we can find the reflection coefficient of any unknown sample. However, to avoid facing multiple solutions, we suggest measuring three quantities, at least one of which must be reflectivity and the others must contain polarization of the reflected beam normal to the magnetization of the magnetic layer and parallel to the sample.

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Keywords: Neutron specular reflectivity; Phase problem; Magnetic reference layer; Polarization

1. Introduction

The use of neutron reflection to study thin films and interfaces has been plagued by the so-called "phase problem" [1]. This problem, widely discussed in neutron reflectometry and other fields such as optics and crystallography, refers to the fact that in reflection experiments only the intensity of the scattered wave is measured, and so similar to any other scattering techniques its phase is lost [2]. Without phase information the least-squares fit methods [3] allow the determination of scattering

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