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Improvement in Sputtering Rate Uniformity over Large Deposition Area of Large-Scale Ion Beam Sputtering System

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A wide bandwidth of the neutron polarization of a neutron polarization device using supermirrors is critically important especially for time-of-flight instruments installed at spallation neutron sources such as the J-PARC MLF since it determines the available wavelength-range of polarized neutrons. The sputtering rate must be uniform over the entire deposition area for the fabrication of the polarizing supermirror because a serious loss in the bandwidth can be caused if the uniformity is not enough. This study is aimed to improve the sputtering rate uniformity over a large deposition area with a diameter of 500 mm of the large-scale ion beam sputtering system. The period thickness depending on the distance from the center of the holder was measured for a periodic Fe/Ge multilayer. A modification of the covered area of the mask as a function of the distance from the center was given by the period thickness data and achieved a uniformity of 0.56% over a large deposition area with a radius of 210 mm. Fe/Ge polarizing supermirror with $m = 5$ fabricated under the same condition showed a spin-up reflectivity and polarization higher than 0.70 and 0.93, respectively.

KEYWORDS: Neutron polarizing supermirror, Ion beam sputtering, X-ray reflectivity, Polarized neutron reflectivity

1. Introduction

A neutron polarizing supermirror is a stack of alternating layers of ferromagnetic and nonmagnetic materials with a variation in bilayer thickness to extend the bandwidth of the neutron-spin polarization [1, 2]. High polarization and wide bandwidth play a critical role in determining the performance of the polarizing supermirror to meet a variety of research demands. For an extension of the bandwidth, it is important to increase the ratio m of the critical momentum transfer of the supermirror to that of natural nickel. Number of researches has been conducted to improve the performance of neutron polarizing multilayers and supermirrors by using evaporation and magnetron sputtering techniques [3–7].

We have developed high-performance neutron polarizing and non-polarizing supermirrors by using the ion beam sputtering (IBS) technique [8–14]. The IBS allows the energy and current density of the primary ions to be controlled independently, in addition to the discharge confined to the sputtering ion source and good vacuum condition due to small amount of sputtering gas required. These advantages over the other sputtering techniques make it possible to fabricate high-performance supermirrors. For the production of supermirror devices such as neutron guides and focusing mirrors, a large-scale IBS system was installed and a sputtering rate uniformity less than 4% over the circular