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# 2.8.5 Characterization of NiCr Thin Film

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In order to enhance the reflectivity of Ni/Ti multilayer mirrors, many improvements have been conducted to decrease the interface roughness of Ni/Ti multilayers, because the large grained Ni layers with a structure of columnar growth lead to rough interfaces with an increase in the number of layers and decrease the reflectivity. In this study, the decrease of crystallization of Ni has been carried out by mixing chromium atoms to Ni layers.

NiCr monolayers with a thickness of 2000Å were deposited with changing Cr mixing ratios in Ni layers. The mixing ratios were 10%, 20%, 30%, 40% and 50%, which were determined by an electron spectroscope for chemical analysis (SHIMADZU ESCA-850). They were coated on Si substrates using an ion beam sputtering technique. The crystal structure and the critical angle of external total reflection of each NiCr monolayer were studied by high angle X-ray diffraction measurements and the neutron reflectometry.

X-ray measurements were performed in a $\theta$-$2\theta$ mode using $CuK_\alpha$ radiation ($\lambda$=1.54Å). Figure 1 shows the observed patterns from the NiCr monolayers as a function of the Cr mixing ratio. At a mixing ratio of 10%, the Ni(111), Ni(200) and Ni(220) textures are clearly observed. The NiCr layer remains crystalline, and forms the cubic structure. At a mixing ratio of 20%, the intensity of the Ni(111) and Ni(200) peaks are reduced. On the other hand, the intensity of Ni(220) peak increases. At mixing ratios of 30% and 40%, Ni(220) orientation are still observed. The shift of Ni(220) peak to lower angle may be due to the solid solution of chromium atoms into Ni layers and the Ni(220) intensity reduction may be due to Ni alloying or amorphization. At a mixing ratio of 50%, Ni crystalline is not observed, and $Cr_3Ni_2$ (Tetragonal) peaks are recorded.

The critical angles of external total reflection of the NiCr monolayers were determined by neutron reflectivity measurements. They were performed in a $\theta$-$2\theta$ mode using the reflectometer installed on the cold neutron triple-axis spectrometer (LTAS, C2-1) at JRR-3M. The wavelength was 3.8Å and the wavelength resolution was 1%. The dimension of the beam was 0.2mm in width and 10mm in height, and the collimation of the beam was achieved by $B_4C$ and Cd slits placed at a distance of 1.5m apart. The obtained critical angles of total reflection were 0.0182Å$^{-1}$, 0.0176Å$^{-1}$, 0.0164Å$^{-1}$, 0.0156 Å$^{-1}$ and 0.0144Å$^{-1}$ as for the Cr mixing ratios of 10%, 20%, 30%, 40% and 50% respectively. The critical angle of total reflection is given by $\phi_c = \lambda(Nb/\pi)^{1/2}$, where N is the average number of atoms per unit volume and b is the bound coherent scattering length. Then Nb were 6.58E+10 cm$^{-2}$, 6.16E+10 cm$^{-2}$, 5.38E+10 cm$^{-2}$, 4.83E+10 cm$^{-2}$ and 4.14E+10 cm$^{-2}$, which were derived from above mentioned results. They are decreased with an increase in the Cr mixing ratio.

From Fig. 1, it is clearly observed that the Ni(111) and Ni(200) textures are reduced, then it is expected to decrease the interface roughness of Ni/Ti multilayers by adding chromium atoms.

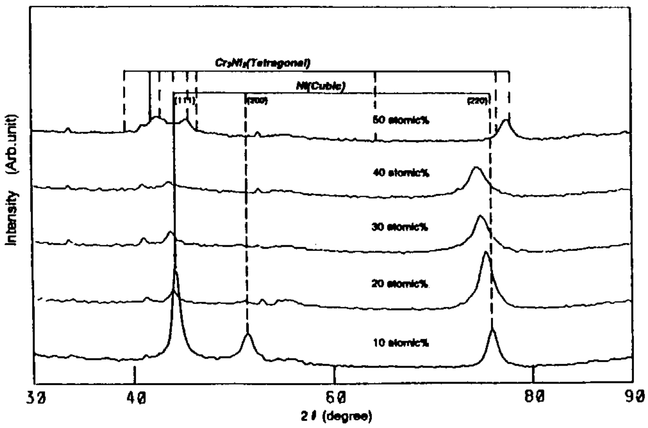


Fig. 1 X-ray diffraction patterns from the NiCr monolayers as a function of Cr mixing ratio.