

Development of advanced multilayer neutron mirrors and focusing device

M. Hino^A, T. Hosobata^B, M. Takeda^B, Y. Yamagata^B, T. Oda^C, H. Endo^D

^AKURNS, Kyoto Univ., ^BRAP, RIKEN, ^CISSP-NSL, Univ. of Tokyo, ^DIMSS, KEK

The actual use of the focusing mirror is very effective in increasing the effective neutron intensity at the sample position, and then it is still a very important development in neutron beam facilities, especially large ones. We have established a fabrication method for a spherically focusing high- m supermirrors with a metal substrate. Where m is the maximum critical angle of the mirror in units of the critical angle of natural nickel. In this study, we report current status on the development of high- m neutron focusing supermirrors.

The metal substrate is robust and ductile, which can produce a steeply curved surface with high shape accuracy. It can also be used under high irradiation and high temperature file, even at a location close to the neutron target and moderator. We have achieved a smooth surface for high- m supermirror coating.

We have fabricated ellipsoidal metal substrates with electroless nickel-phosphorus (NiP) plating based on the technology of ultra-high precision cutting with corrective machining followed by mechanical precision polishing. The first precision manufacturing was carried out on a CNC machine for the development of neutron optical devices in KURNS workshop. Ultra-precision machining, polishing and cleaning of the metal substrate were carried out at RIKEN. The supermirror coating was performed using an ion beam sputtering machine at KURNS (KUR-IBS) [1]. Figure 1(a) shows a typical photo of an ellipsoidal supermirror deposited on LOT and silicon substrates. The semi-major and semi-major axes of the ellipsoidal supermirror were 1250 mm and 65.4 mm, respectively. Finally, we fabricated $m=6$ NiC/Ti(C) supermirrors in which the effective number of layers was 9750, with half of the layers being very thin carbon interlayers. The neutron experiments were performed at the C3-1-2(MINE) port of JRR-3.

By adding very thin carbon interlayers between NiC and Ti layers, we realized $m=6$ supermirrors with high reflectivity. There was a bit difference each LOT because some condition was difference as following: Because cleaning condition was a bit difference between LOT21 and LOT22, and the deposition rate of Ti target of LOT18 was smaller than those of LOT21 and LOT22.

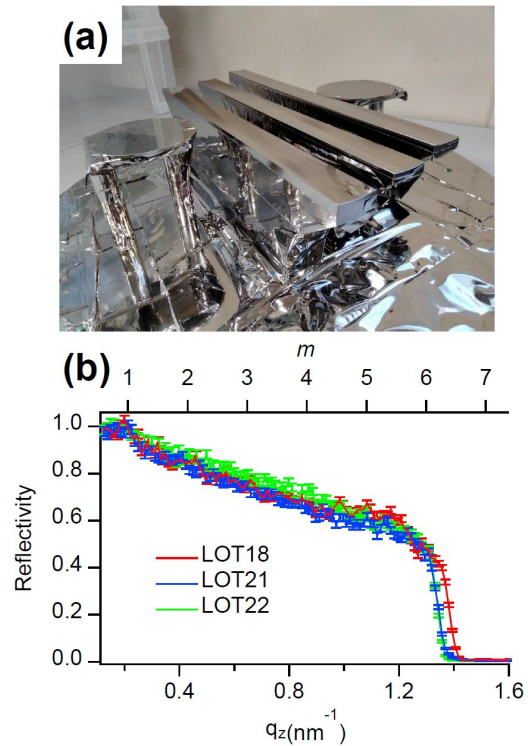


Fig. 1. (a) The photograph of $m=6$ supermirror deposited on one LOT (three ellipsoidal metal substrates) and two Si wafers (b) Neutron reflectivity of the supermirrors on Si wafers of which LOT number are 18, 21 and 22.

[1] M. Hino, et al., Nucl. Instr. and Meth., 797(2015) 265.