Development of wide-bandwidth half mirror for neutron interferometer

M. Kitaguchi[A], T. Fujiie[A], H. M. Shimizu[A], K. Mishima[B], G. Ichikawa[B], T. Hosobata[C], Y. Yamagata[C], Y. Seki[D], and M. Hino[E]

[A]Nagoya Univ., [B]KEK, [C]RIKEN, [D]Tohoku Univ., [D]KURNS, Kyoto Univ.

Neutron interferometry is a powerful technique for studying fundamental physics. Numerous interesting experiments [1] have been performed since the first successful test of a single-crystal neutron interferometer [2]. However, the single-crystal interferometer is inherently not able to deal with a neutron that has a wavelength longer than twice its lattice constant. In order to investigate problems of fundamental physics, the interferometry with cold neutrons is extremely important, since the sensitivity of interferometer for small interaction increases with the neutron wavelength. One of the solutions is an interferometer using neutron multilayer mirrors [3]. We succeeded in developing a multilayer interferometer for cold neutrons in which two paths are completely separated for the first time using wide-gap etalons at MINE in JRR3 [4].

In the case of pulsed neutron beams, the intensity at each wavelength can be resolved with the arrival time on the detector. When the multilayer mirrors are applied to pulsed neutrons, the interference fringes at each wavelength can be observed simultaneously. We have already installed the interferometer into the beamline J-PARC MLF BL05 to demonstrate the interferometer with pulsed neutrons (Fig. 1). In this demonstration, the bandwidth of neutrons was narrow because of the monochromatic multilayer mirrors. For next steps, the wide-bandwidth of neutron wavelength should be used to increase the statistics. Neutron supermirrors can be applied for total reflective mirrors, however, half mirrors with wide-bandwidth, which are required as a splitter and analyzer in the interferometer are unprecedented.

In this study, we have developed the half mirrors with wide-bandwidth. The multilayer mirrors were fabricated with ion beam sputtering in KURNS. The reflectivity was measured with neutron reflectometer at MINE in JRR3. The range of half-mirror was as designed, momentum transfer between 0.4-1.1 nm^{-1} (Fig. 2), however, the absolute values of reflectivity were unstable due to fabrication lot. This means that sputtering conditions need to be investigated.

[1] H. Rauch and S. Werner, Neutron Interferometry Oxford University Press, Oxford, 2000; J. Byrne, Neutron, Nuclei and Matter Institute of Physics Publishing, London, 1994, Chap. 7; Mater Wave Interferometry, edited by G. Badurek, H. Rauch, and A. Zeilinger North-Holland, Amsterdam, 1988.
[2] H. Rauch, W. Treimer, and U. Bonse, Phys. Lett. 47A, 369 (1974).
[3] M. Kitaguchi, et.al., Phys. Rev. A 67, 033609 (2003).
[4] Y. Seki, et. al., J. Phys. Soc. Jpn. 79, 124201 (2010).

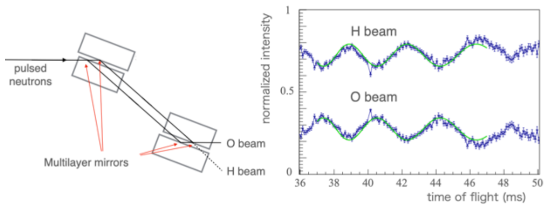

Fig. 1. Interference fringes according to time-of-flight of pulsed neutrons at BL05 in J-PARC.

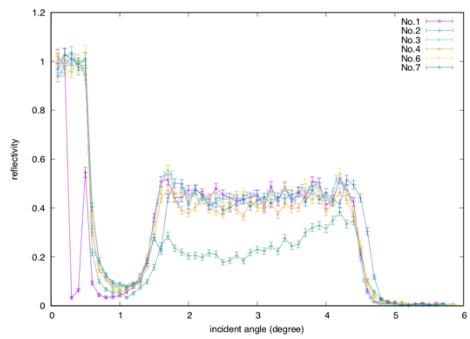

Fig. 2. Reflectivity of wide-bandwidth half mirrors. The wavelength of incident neutrons was 0.88 nm at MINE. Colors indicate the fabrication lots.