

Characterization of diamond-like carbon coating for ultracold neutron applications by neutron reflectometry

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Ultracold neutrons (UCNs), neutrons with kinetic energies on the order of 100 neV or lower, can be stored in a vessel coated with materials of high Fermi potential, making them a unique tool for particle physics experiments with neutrons. Coating of UCN guides and storage cells is therefore a key technology that impacts a wide range of experiments. In this context, we developed a Pulsed Laser Deposition (PLD) facility at the University of Winnipeg for applying diamond-like carbon (DLC) coatings to UCN guides [1]. DLC is a class of amorphous carbon materials widely used in industrial applications, characterized by the ratio of sp^3 -bonded (“diamond-like”) to sp^2 -bonded (“graphite-like”) carbon atoms. For UCN applications, the PLD parameters should be adjusted to produce highly diamond-like films with high density.

Neutron reflectometry is an effective method for testing these DLC films, enabling us to determine the effective Fermi potential experienced by neutrons. Using 0.88-nm wavelength monochromatic neutrons at JRR-3/MINE2, we characterized samples produced at the PLD facility in Winnipeg. Here, we report results obtained in FY2024. Two DLC film samples deposited on silicon wafers under different PLD conditions were tested. As reference samples, NiC and carbon films sputtered onto glass substrates were prepared at the ion beam sputtering (IBS) facility at the Institute for Integrated Radiation and Nuclear Science, Kyoto University [2]. The results summarized in Fig. 1 and Table 1 show that the second sample, produced later, exhibited a higher critical momentum transfer q_c , corresponding to a larger effective potential.

We plan to continue this project to further evaluate samples and optimize the PLD production parameters, with the goal of

achieving reliable production of high-potential coatings.

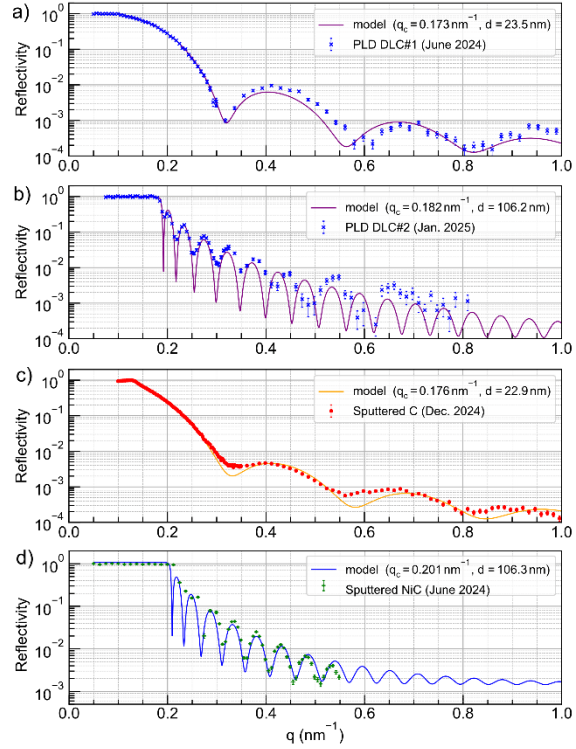


Fig. 1 Reflectometry data obtained for two DLC films produced by PLD and sputtered carbon and NiC films

Table 1 Fit results of the reflectometry data presented in Fig. 1 to a reflectivity model of a single-layer film. The results on the critical momentum transfer q_c and the layer thickness d are reported.

Sample	q_c (nm ⁻¹)	d (nm)
DLC #1 (PLD)	0.1732 (6)	23.5 (2)
DLC #2 (PLD)	0.1824 (3)	106.0 (8)
Carbon (IBS)	0.1762 (2)	22.9 (1)
NiC (IBS)	0.201 (1)	106.3 (6)

- [1] R.R. Mammei, PhD thesis, Virginia Polytechnic Institute and State University (2010).
- [2] M. Hino *et al.*, Nucl. Instr. and Meth. A, **797**, 265 (2015).