Development of Neutron Gas Scintillation Imager with Capillary Plate-II

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Neutrons are sensitive to light elements such as hydrogen, lithium, boron, carbon, and magnetic elements in the samples. Recently, neutron radiography has started to be used in various studies such as the visualization of lithium and water molecules inside batteries, the corrosion inspection of metal materials, and the inspection of rocket parts. High-resolution imaging capability with a moderate effective area is required in practical applications of neutron imaging. We have been developing a high-spatial-resolution neutron gas scintillation imager (n-GSI) with a capillary plate gas detector (CPGD) [1,2]. The performance of n-GSI was investigated using the JRR-3M MINE1 beamline. The neutron wavelength giving the maximum intensity and the total flux of the MINE1 guide tube were 8 Å and 1×10^{6} neutrons $cm^{-2}\ s^{-1}$, respectively.

Fig. 1 shows a schematic view of n-GSI consisting of a conversion layer containing $^{10}B_4C$ deposited on a Si substrate and a CP placed in a vessel. The CP has an effective diameter of 25 mm, an thickness of 300 μm, an individual hole diameter of 50 μm, and pitch of 64 μm. The vessel is filled with a Ne (90%) + CF_4 (10%) gas mixture. A $^{10}B_4C$ converter is directly mounted on the inlet surface of the CP. Charged particles (α-rays and ^{7}Li nuclei) are generated by the nuclear reaction between incident neutrons and ^{10}B.

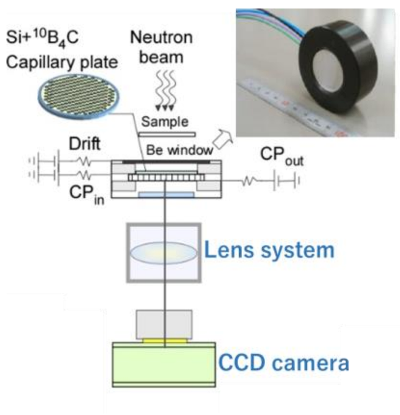

Fig. 1. Schematic view of n-GSI

The charged particles ionize the gas molecules, resulting in the generation of electrons in the gas. Scintillation light is emitted from capillary holes upon gas excitation simultaneously with electron multiplication. The scintillation light from each capillary hole is read out as an imaging signal through the lens system using a CCD camera. Neutrons are irradiated through a test chart made by using a Gd slit on a thin glass sheet.

The test chart of the line pair is shown in Fig. 2 a). Fig. 2 b) shows the neutron transmission image of the test chart obtained using n-GSI. The exposure time was 10 min. The numbers in Fig. 2 b) indicates the width of the slit on the chart. Fig. 2 c) shows the projections of line profiles within the solid and dashed boxes in Fig. 2 b). The practical position resolution of n-GSI is estimated to be 70 μm for the neutron beam. To improve the position resolution, we are currently developing an n-GSI using the new CP.

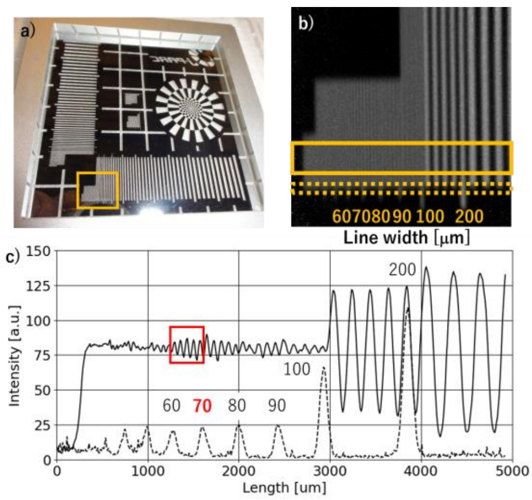

Fig. 2. a) Gd test chart. b) Neutron image of a neutron test chart obtained using n-GSI system. c) Projections of line profiles within the solid and dashed boxes in Fig. 2 b).

[1] H. Kondo et al., Plasma Fusion Res. 13 (2018) 2406018.

[2] H. Kondo et al., Nucl. Instrum. Methods Phys. Res. A 958 (2020) 162804.