Development of Neutron Gas Scintillation Imager with Capillary Plate

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Since neutrons and X-rays have different cross sections for materials, their complementary use enables us to investigate the interior of matter in more detail. In particular, neutron radiography has started to be used in new fields such as the visualization of lithium and water molecules inside batteries, the corrosion inspection of metal materials, and the inspection of rocket parts. We have been developing a high-spatial-resolution neutron gas scintillation imager with a capillary plate gas detector (n-GSI) with a capillary plate gas detector (CPGD) [1,2]. Fig. 1 shows a schematic view of the n-GSI. This n-GSI consists of a conversion layer containing $^{10}B_4C$ deposited on a Si substrate and a CP placed in a vessel. The vessel is filled with 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 ^7Li nuclei) are generated by the nuclear reaction between incident neutrons and ^{10}B. 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 holes is read out as an imaging signal through the optical mirror and lens system using a CMOS camera. The imaging capability of the n-GSI was investigated using the cold neutron beamline CN-3 installed at the Kyoto University Reactor (KUR) [2]. The CP has an effective diameter of 27 mm and a thickness, an individual hole diameter, and pitch of 300 μm, 50 μm, and 64 μm, respectively. We obtained a spatial resolution of 80 μm in the performance test using a Gd test chart.

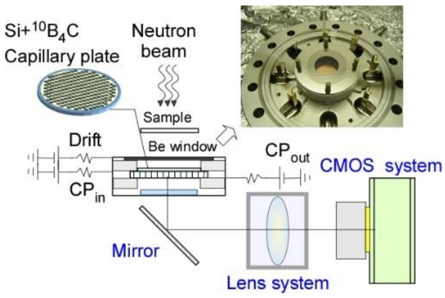

Fig. 1. Schematic view of n-GSI

Since the wavelength of neutron between KUR and JRR-3M, the operation test of this n-GSI was carried out using the JRR-3M MINE beamline. The anode currents were measured by varying the applied voltage across the CP electrode (ΔV_{CP}). Fig. 2 shows the anode gain normalized using the anode current at ΔV_{CP} = 570 V. The anode gain increases exponentially with the gap voltage across the CP. This result indicates that the n-GSI operates as a gas proportional counter. In the future, we will develop a new CP with a funnel-shaped structure, an individual hole diameter of 25 μm, and a pitch of 30 μm. Then, we plan to develop an n-GSI using the new CP and aim for a spatial resolution of 50 μm.

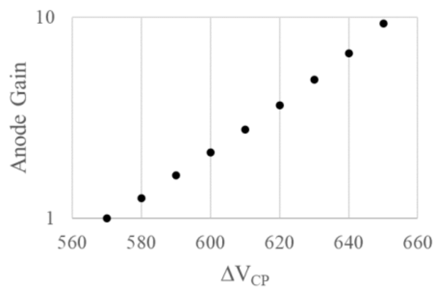

Fig. 2. n-GSI anode gain as a function of voltage across the CP electrode.

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

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