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Large area MCP-based neutron imagers

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Neutron imaging detectors based on neutron-sensitive microchannel plates (MCPs) were constructed and tested at beamlines of thermal and cold neutrons. The MCPs are made of a glass mixture containing enriched boron and natural gadolinium, which makes the bulk of the MCP an efficient neutron converter. Contrary to the neutron-sensitive scintillator screens normally used in neutron imaging, spatial resolution is not traded off with detection efficiency. While the best neutron imaging scintillators have a detection efficiency around a percent, a detection efficiency of around 50% for thermal neutrons and 70% for cold neutrons has been demonstrated with these MCPs earlier.

In our tests we coupled a neutron-sensitive MCP to a phosphor screen which was read by a low-noise CMOS camera. Images of a gadolinium test mask designed for this purpose show a limiting resolution of about 50 µm. We will show images and tomographic reconstructions made with thermal and cold neutrons.

A first prototype of this concept had a modest size of 40 mm active diameter. A new unit is now available with a 100×100 mm^2 active area. This detector does not have the limitations in rate capability and active area coverage that are seen in imaging detectors with electronic readout structures, while being orders of magnitude more sensitive than other detectors with optical readout like scintillators. Also the afterglow known from neutron imaging scintillation screens is completely absent.

The phenomenal detection efficiency over the large active area will change the field of neutron tomography. Where nowadays it is common to acquire ~800 projections in about a day of exposure, our detector can complete this in about an hour. The fact that many times less neutron flux is integrated to attain a certain image quality also means that samples activate less, proportionally to exposure time. Rare artifacts and valuable museum pieces can be imaged and still return to their owner. Small, low power nuclear reactors running on conventional low-enriched uranium become suitable neutron sources for imaging. The images in this study taken at the research reactor in Delft are a case in point. We are exploring the possibility of neutron imaging with neutron generators, which may take neutron imaging from large scale user facilities to labs in academia and industry.

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