Contribution ID: **251** Type: **Oral presentation**

Radiation Damage Study of the ePix100 Detector at the European XFEL

Thursday 1 July 2021 11:00 (20 minutes)

Operation of detectors at free-electron laser (FEL) facilities with sources providing high brilliance, high repetition rate and ultra-short X-ray pulses poses high risk of radiation damage to detector components exposed to X-ray radiation, e.g. the sensor and the readout Application Specific Integrated Circuit (ASIC). Knowledge about radiation-induced damage is important for understanding its influence on the quality of scientific data and the detector's lifetime.

The ePix100 detector [1] is a hybrid pixel detector designed for low noise spectroscopy applications and is a member of the ePix detector family providing hybrid pixel detectors to support a wide range of applications at FEL facilities. At the European XFEL (EuXFEL) the ePix100 is used at two scientific instruments, namely High Energy Density Matter (HED) [2] and Material Imaging and Dynamics (MID) [3].

The aim of our study was to evaluate influence of radiation induced damage by the EuXFEL beam on the performance and lifetime of the ePix100 detector. The detector was irradiated under controlled conditions by a direct attenuated beam with a photon energy of 9 keV and a beam energy of 1 μJ. An area of 20 pixels $\times$ 20 pixels was irradiated to a dose of approximately 760 kGy at the location of the Si/SiO_2 interface in the sensor. The performance changes of the ePix100 detector induced by radiation damage were evaluated in terms of offset, noise, energy resolution and gain. We have observed a dose dependent increase in both offset and noise and the results suggest the main cause being the increase of the sensor leakage current. Energy resolution given as Full Width at Half Maximum (FWHM) was increasing by $\approx$ 115 eV/kGy and can also be attributed to an increase of the noise. Changes in gain were evaluated one and a half hours and 240 days post irradiation. The observed gain changes suggest damage to occur also in the ASIC. Based on the obtained results, we have assessed limits for the long term operation of the ePix100a at EuXFEL and other light sources in terms of its scientific performance. The detector can be used without significant degradation of its operation performance for several years if the incident photon beam intensities do not outperform the detector's dynamic range by several orders of magnitude.

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[2] HED. Scientific Instrument HED. EuXFEL Webpage, 2021. Status March 2021.
[3] A. Madsen, J. Hallmann, G. Ansaldi, T. Roth, W. Lu, C. Kim, U. Boesenberg, A. Zozulya, J. M¨oller, R. Shayduk, M. Scholz, A. Bartmann, A. Schmidt, I. Lobato, K. Sukharnikov, M. Reiser, K. Kazarian, and I. Petrov. Materials Imaging and Dy- namics (MID) instrument at the European X-ray Free-Electron Laser Facility. Journal of Synchrotron Radiation, 28(2):637–649, Mar 2021.

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Session Classification: Oral presentations

Track Classification: Applications