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X-ray measurements of the effects of radiation damage in the miniMALTA DMAPS prototype

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We present tests with a scanning micro-focus photon beam of the miniMALTA DMAPS prototype developed for ATLAS ITk. Tests were carried out at Diamond Light Source which provided a 2um beamspot to be scanned in 1um steps. This allows the in pixel efficiency to be measured directly with high statistics. Three pixel design variations were measured, the standard design, a deeper p well design and an n gap design. This was repeated for an unirradiated chip, a neutron irradiated device and three proton irradiated samples. We compare the effect of different levels of radiation damage on the different pixel designs.

Summary

This contribution presents the results of investigations into the effects of radiation damage on different pixel designs included in the miniMALTA depleted monolithic pixel sensor prototype. MiniMALTA is a prototype test chip developed for the ATLAS ITk project, and contains a number of different pixel designs. We carefully studied the effect of radiation damage for three of these pixel sub matrices in this series of measurements. These were the standard MALTA baseline design, and two variant designs, one with an increased depth of the p-well, and one with a gap in the n-type layer. We used an 8keV micro-focus beam at the Diamond Light Source facility's B16 beamline to scan the pixels with a 2um beam spot in 1um steps to produce a measurement of in-pixel efficiency. An 8 keV beam energy was selected as this best matched the measured energy deposition from a minimum ionising particle in the depleted layer of miniMALTA. We tested chips that had suffered no radiation damage, 1e15 n/cm2 neutron damage, and three chips that had suffered proton damage from 27MeV protons at the Birmingham cyclotron at 7e14 and 5e14 n/cm2. We present and discuss the effect of these different damage levels on the three different pixel designs (MALTA, 'n-gap'& 'p-well'). We analyse the shape of the resultant charge collection efficiency maps, how the damage influences it, and how it is linked to the shape of the underlying collection nodes. We also discuss the effect of radiation damage on the absolute efficiency of the pixel and its effect on the charge sharing region between neighbouring pixels.

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