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(Invited) DEPFET detectors for applications in astrophysics and photon science

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DEPFET detectors for applications in astrophysics and photon science

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The DEPFET (DEpleted P-channel FET) is a combined detector-amplifier structure suitable for a wide range of applications. It has outstanding properties, like excellent energy resolution, high readout speed, low noise, charge storage for readout on demand and low power consumption which is highly valuable for space applications. Due to its versatile design options, the DEPFET pixel can be tailored to meet the specific experimental requirements, for example the pixel size can be easily adjusted by design to the optics point spread function. Advanced developments of specialized DEPFET pixel designs provide various new capabilities, like DEPFETs with a tunable non-linear amplification, others with intrinsic electronic shutter or sub-electron noise, and a new concept to minimize deadtime.

Detectors based on DEPFET technology are now considered for and implemented in projects in the fields of astrophysics (BepiColombo, ATHENA), photon science (European XFEL) and high energy particle physics (BELLE-II). In the following, the DEPFET developments for the projects EuXFEL and the MIXS instrument on BepiColombo will be discussed

Photon Science: One of the X-ray imaging detectors which is currently developed for the European XFEL is the DSSC (DEPFET Sensor with Signal Compression). The detector is optimized for photon counting at low X-ray energies and designed to operate at frame rates up to 4.5 MHz. For XFEL, the DEPFET design was customized in such way, that the DEPFET has intrinsic non-linear signal amplification in order to provide high dynamic range with simultaneous single photon resolution for low-energy X-ray photons. The full sensor will have 1024x1024 pixel and is subdivided into an array of 32 sensor chips with 128x256 pixel each. The size of the hexagonal pixels is 204x236 μm^2.

Planetary Science: The Mercury Imaging X-ray Spectrometer (MIXS) is a two-channel instrument on board of the 5th ESA cornerstone mission BepiColombo, dedicated for imaging x-ray spectroscopy of the Mercury surface. The detector plane arrays (DPA) for the energy and spatial resolved detection of x-rays are based on DEPFET (Depleted P-channel FET) macropixel detectors with each 64x64 pixel and 300x300 μm^2 pixel size. The readout time for a full detector frame is 170 µs. The MIXS target energy band is from 0.5 to 7 keV with an energy resolution better than 200 eV at 1 keV at mission end, despite the harsh radiative environment. This allows to access the Fe-L line at about 0.7 keV, which was not accessible to previous instruments, and to separate the x-ray lines of the elements of interest. The flight grade DPAs are calibrated and now in the stage of implementation into the MIXS flight instrument. MIXS will be the first space borne instrument equipped with DEPFET detectors.

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