

The X-ray Evolving Universe Spectroscopy (XEUS) mission is currently under study by the European Space Agency as a potential follow-up of XMM-Newton. As XEUS will exceed current observatories drastically in collecting area new detector systems with count rate capability must be considered for the focal plane instrumentation. A promising candidate for the XEUS Wide Field Imager is the Active Pixel Sensor (APS) with each pixel having its own integrated, individually addressable preamplifier. Our APS concept is based on the monolithic detector-amplifier structure DEPFET (DEpleted P-channel Field Effect Transistor).

The DEPFET is a p-channel field effect transistor on high resistivity n-type silicon bulk (fig. 1). The bulk is completely depleted by the reverse biased backside diode thus creating a potential minimum for electrons close to the surface, which is enhanced by an additional deep n-doped region. Each electron released in the depleted volume below the transistor by the absorption of ionizing radiation will drift to this 'internal gate' and enhance the transistor current by inducing an additional positive image charge inside the FET channel. Thus the DEPFET's current is a function of the amount of charges in the potential minimum. The reset of the internal gate is done through an adjacent n+-doped 'clear' contact. The spectroscopic quality of single DEPFET devices was demonstrated by a measured equivalent noise charge (ENC) of 4.6 el. rms at room temperature (fig. 2). In a DEPFET the signal charges are strictly confined in a potential well. Thus the information, i.e. the number of charges in the internal gate, is conserved during the readout and available for repetitive readings with subsequent averaging and further noise reduction.

The matrix-like formation of DEPFETs with common back contact results in an APS with low noise, low power consumption, random-accessible pixels, high-speed readout by parallel multi-channel processing, a 100 % fill factor by backside illumination, and high quantum efficiency by an optimized entrance window and by full depletion.

In its final version the focal plane APS will be composed of 1024 x 1024 DEPFETs with a pixel size of 75 x 75 μm^2 resulting in a total sensor area of 7.68 x 7.68 cm^2 (fig.3). On the way to the proposed XEUS Wide Field Imager prototype APS devices with 64 x 64 pixels are currently in production.

References

- J. Kemmer, G. Lutz, *New detector concepts*, NIM A253 (1987) 365
- L. Strüder, *High-resolution imaging X-ray spectrometers*, NIM A454 (2000) 73

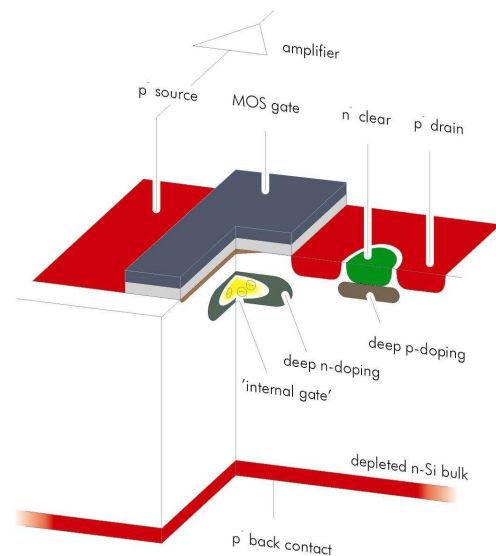


Fig. 1 Cross section of a DEPFET. Signal electrons collected in the 'internal gate' steer the transistor current.

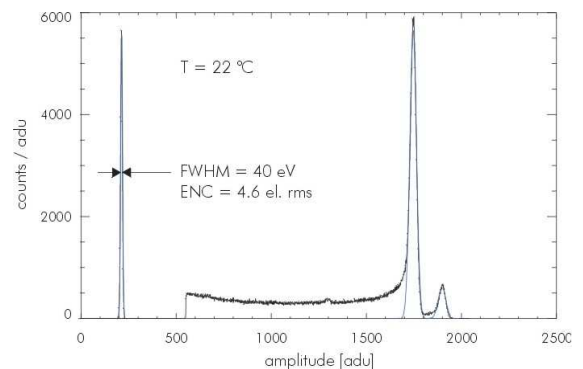


Fig. 2 Spectrum of a radioactive Fe-55 source recorded with a DEPFET at room temperature.

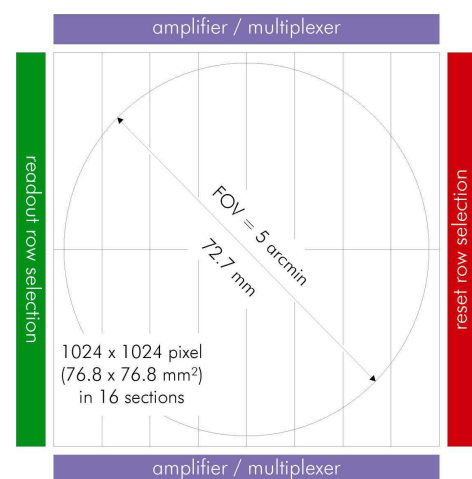


Fig. 3 Layout of the XEUS Wide Field Imager focal plane. The APS with 1024 x 1024 pixels is switched on and off and reset row-wise by the control electronics units at the left and right sides. The vertical channels of the APS are read out in parallel by the amplifier/multiplexer chips at the bottom and top side.