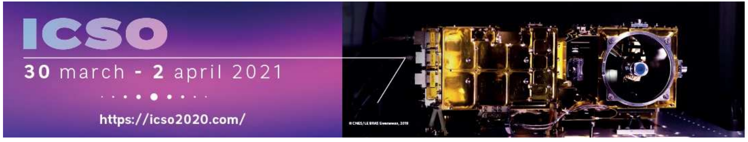

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VIRTUAL

CCD272-64 and GSENSE400BSI-GP CMOS quantum efficiency measurement in EUV and VUV

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We have measured the spectral quantum efficiency of several digital detectors in two spectral ranges, namely vacuum ultraviolet (VUV, 115-310 nm) and extreme ultraviolet (EUV, 10-58 nm) wavebands. We used monochromatic synchrotron radiation from the VEPP-4M storage ring (INP, Novosibirsk) to investigate the spectral response of GSENSE400BSI-GP CMOS which have been specially designed for optimum VUV sensitivity, as well as the WSO-UV project's custom deep cooled CCD272-64 sealed within a hermetic contaminant-protective stainless-steel enclosure with a VUV-transparent entrance window.

The CMOS GSENSE400BSI-GP sensitive surface has four types of different pretreatment: (i) small boron implantation dose, weak annealing; (ii) small boron implantation dose, strong annealing, (iii) large boron implantation dose, weak annealing; (iv) large boron implantation dose, strong annealing. These VUV optimized CMOS sensors have higher spectral sensitivity and higher quantum efficiency in the 112-180 nm spectral range, compared to a commercial CMOS typically optimized for the best performance at visible wavelengths, but at longer wavelengths the GP CMOS sensitivity decreases.

CCD272-64 for the WSO-UV space project

The custom radiation hard UV enhanced CCD272-64 was developed by Teledyne e2v for the WUVS spectrograph of the World Space Observatory Ultraviolet (WSO-UV) project.
The operating spectral range of the CCD is 115-310 nm.

The key features of the WUVS detector subsystem are:

- Custom CCD272-64, 4096 × 3112 pixels of 12×12 μm
- Enhanced FUV and NUV sensitivity
- Design to operate with very low level signals at a long exposure time in a Space environment
- Gradient AR coating for the 174-310 nm spectral range (UVES and LSS channels)
- Custom hermetic cryostat to provide CCD operating temperature at -100 °C
- Protective UV-transparent window made of MgF_2
- Digital Correlated Double Sampling video processing with a flexible readout
- The readout noise of about 3 e⁻ rms at 100 kHz

WUVS CCD and custom hermetic Enclosure were designed and built by Teledyne e2v (UK).

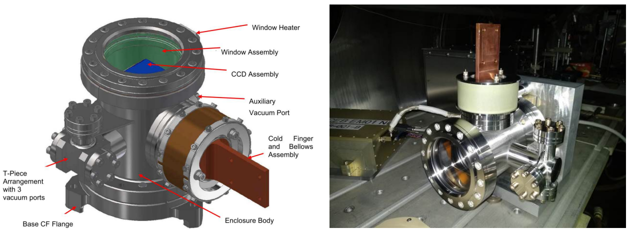

Fig. 1. External view of the CCD-containing stainless-steel enclosure with MgF_2 protective window and Cu 'Cold Finger'.

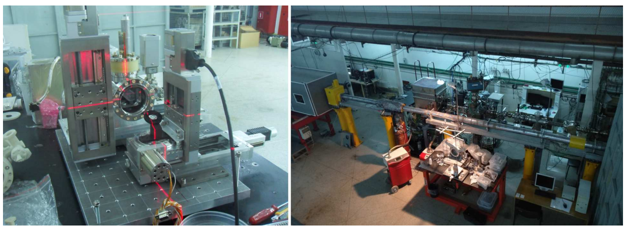

Fig. 2. CCD272-64 EQM Enclosure at "Kosmos" metrological station (VEPP-4M synchrotron) during quantum efficiency measurements (INP, Novosibirsk, Russia).

GSENSE400BSI-GP CMOS sensors

GSENSE400BSI-GP CMOS sensor was designed and built by GPixel company (China).

This is a special VUV-dedicated CMOS sensor with a sensitive area of 22.528 × 22.528 mm, 2048 × 2048 pixels of 11 × 11 μm size.

We measured 4 versions of this sensor, each with a specific treatment of the back surface: large boron implantation, strong/weak annealing; and smaller boron implantation, strong/weak annealing (see Table 1).

We also measured the spectral sensitivity of a commercially available UV-optical version of the same CMOS, named TVISB.

Table 1. Description of the GSENSE400BSI-GP CMOS sensor labels.

CMOS Part Label	Boron Ion Doping	Annealing Degree
LB-SA	Large Boron Implantation Dose	Strong Annealing
LB-WA	Large Boron Implantation Dose	Weak Annealing
SB-SA	Small Boron Implantation Dose	Strong Annealing
SB-WA	Small Boron Implantation Dose	Weak Annealing

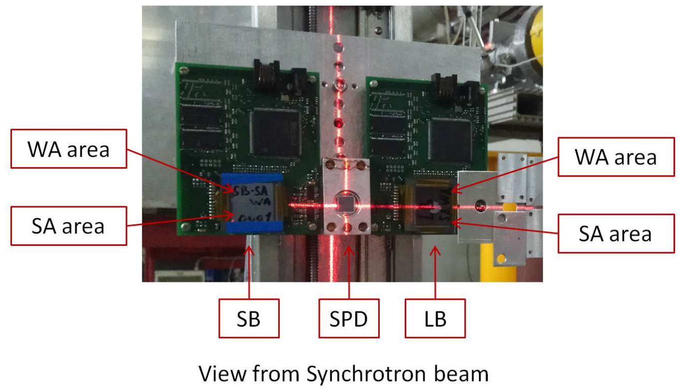

Fig. 3. External view of the GSENSE400BSI-GP CMOS matrices in question mounted on a translation stage with a calibrated photodiode SPD.

Results of the Quantum Efficiency measurements

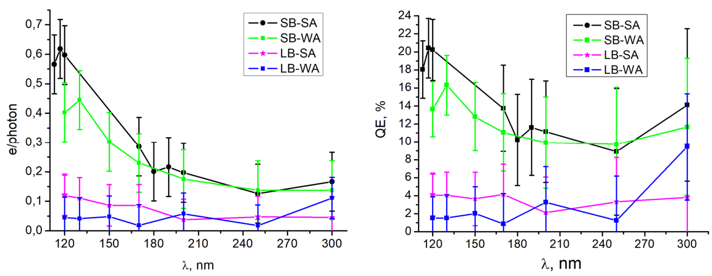

Fig. 4. Experimental results of the CMOS spectral sensitivity (left) and the CMOS quantum efficiency (right) in VUV.

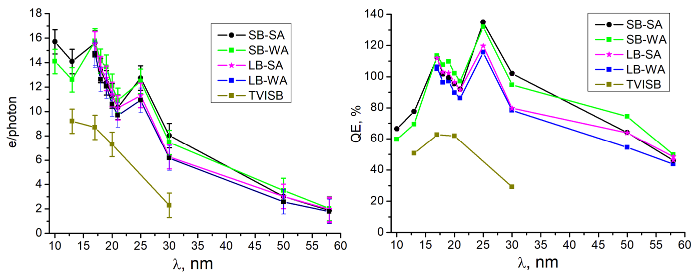

Fig. 5. Experimental results of the CMOS spectral sensitivity (left) and the CMOS quantum efficiency (right) in EUV.

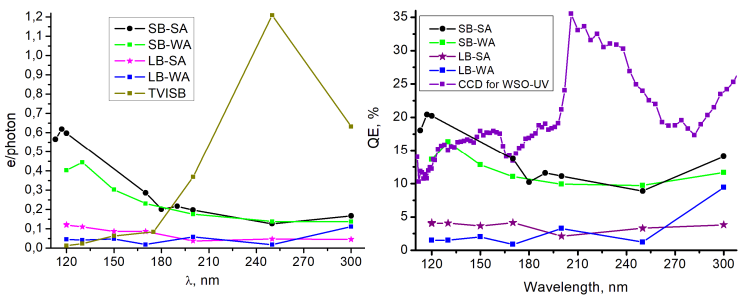

Fig. 6. Comparison of the GSENSE400BSI-GP CMOS and TVISB CMOS spectral sensitivity in VUV (left); comparison of the CCD272-64 for the WSO-UV and GSENSE400BSI-GP CMOS quantum efficiency in VUV (right).

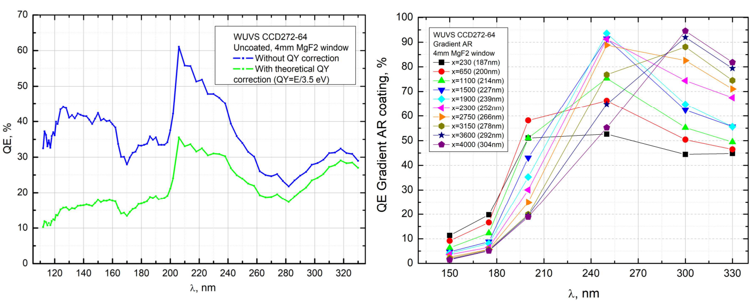

Fig. 7. CCD272-64 quantum efficiency measurement results (INP, Russia): uncoated region of the CCD (left), gradient AR coating region of the CCD (right).