Research and Development Centre for Advanced X-ray Technologies

The Centre was established in 2012 within a project of Structural Funds (ITMS code 26220220170) with the aim to strengthen collaboration between the three partners: Integra TDS company, Institute of Physics and Institute of Electrical Engineering, Slovak Academy of Sciences. The main objectives of common research are:

- advanced technologies for fabrication and shaping of high-quality active surfaces of the crystal X-ray optics with sub-nanometre local roughness
- design and fabrication of new monolithic elements of the crystal X-ray optics such as multi-functional channel-cut monochromators for the compression or expansion of the X -ray beam
- custom-designed polylithic systems of X-ray optics based on planar monochromators
- high-quality substrates and protective coatings for interference multilayer X-ray mirrors
- dedicated diagnostics of the surface quality and subsurface damage of the crystal lattice ranging from nanometers to millimeters based on a number of complementary methods (multimode atomic force microscopy, stylus profilometry, Raman confocal microscopy, laser scatterometry, imaging and spectroscopic ellipsometry, X-ray reflectometry, high-resolution X-ray diffractometry)
- relation between quality of the surface and crystal lattice in terms of local roughness, stress, lattice defects etc. and performance of the elements of the crystal X-ray optics
- application of the X-ray beam expanders to modern X-ray imaging and tomography methods with high spatial resolution using phase-contrast (refractive) mode
- application of the X-ray beam compressors to the X-ray metrology and design of new cost-effective measurements setups (techniques of small- angle X-ray scattering or medium-resolution X-ray diffraction)
- X-ray and Gamma detectors working in single photon counting regime

Integra TDS, s. r. o.

Institute of Physics

Institute of Electrical Engineering

RESEARCH AND DEVELOPMENT CENTRE FOR ADVANCED X-RAY TECHNOLOGIES

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established in 2012

Partners:

Integra TDS, s. r. o.

Slovak Academy of Sciences

Institute of Electrical Engineering (IEE SAS)

Institute of Physics (IP SAS)

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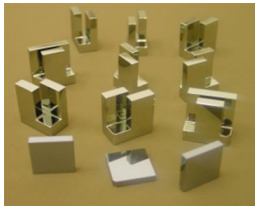
Európska únia

„ Podporujeme výskumné aktivity na Slovensku/Projekt je spolufinancovaný zo zdrojov EÚ"

Integra TDS, s.r.o. is a kind of spin-off company (SME) from academy specialized in precise crystallographically oriented shaping of crystals, mainly germanium and silicon. Through its staff it has a number of collaborations and has been involved in numerous national and international research projects. It has expertise in various specialized X-ray optics not only for diffractometry, but also for other fields of laboratory and synchrotron X-ray techniques and technologies, including HRXRD, reflectometry, SAXS, GI-SAX, X-ray imaging, low background sample supports. Preparation of elements for X-ray optics based on crystals is often based on a two step procedure: first the crystal is cut by using a diamond saw or a wire saw and then a modern way of preparing flat or curved crystal surfaces based on ultra-precision machine systems supporting single point diamond turning (SPDT), fly-cutting and deterministic micro-grinding tools is performed. New diffractometer D8 form Bruker allowing high resolution X-ray diffraction (HRXRD) is used for X-ray analysis of produced crystal optics. X-ray crystal optics (Ge, Si, GeSi, Cu) can be used for metrology and imaging (8-20 keV).

V-channel-cut crystals

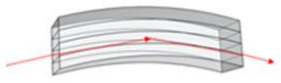


Various shapes of X-ray crystal optics

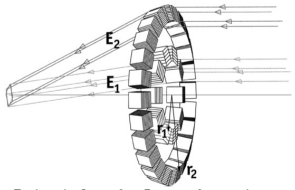
Nanotech 350FG Moore nano-machining centre

Diffractometer D8 Discover

The expertise of the Integra TDS and **Institute of Electrical Engineering, SAS** in design of X-ray crystal optics is being used within a collaboration with CNR-IMEM Parma in development of curved focusing crystal optics. This optics can be used for hard X-ray astronomy or medical imaging using Gamma rays. The characterization was done for high energy of 120 keV in Laue transmission geometry using 1x1 mm^2 beam dimension. The 0.5 mm thick and 8 mm long GaAs bent crystal with radius of 40 m was used for characterization. The increase of the diffraction efficiency in the bent crystals was observed.



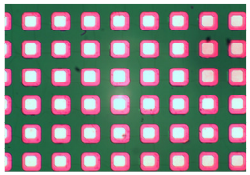
Bent crystal in Laue transmission gemotery



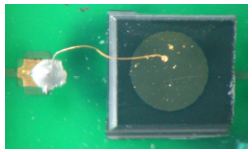
Principle of a Laue focusing multiple crystal monochromator designed for two photon energies E_1 and E_2 within the range of high energy γ-ray astronomy

X-ray, Gamma-ray and neutron detectors

At the IEE SAS prepared primarily Schottky barrier semiconductor detectors based on semi-insulating GaAs and 4H-SiC. Detectors can be optimized for detection of X-ray, Gamma ray, heavy charge particles or neutrons. Small pixel detectors can be used for imaging applications and single larger area detectors for dosimetry or ionizing radiation monitoring.



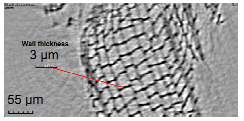
X– and γ– rays pixel detector based on semi-insulating GaAs.



Single detector of neutrons based on 4H-SiC

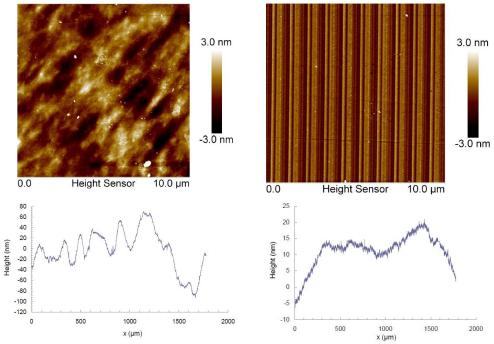
X-ray phase contrast imaging and tomography

The field of X-ray Phase Contrast Imaging (PCI) has been rapidly growing over the last decade, with many applications in materials science and the life sciences. Within a progress of previous projects a microtomographic X-ray imaging system was designed and self-constructed in workplace of IEE SAS in Piešťany. The microtomographic X-ray imaging system is based on a free space propagation imaging technique including the phase contrast tomography.



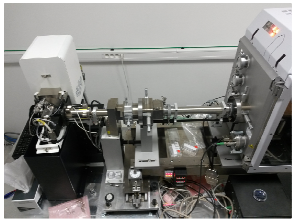
Phase contrast tomographic slice of wooden sample

The experise of the **Institute of Physics, SAS** covers characterization and testing of X-ray optics using AFM, profilometry, Raman spectroscopy, optical microscopy, X-ray diffraction and scattering, especially the so called GISAXS.



Left column: Standard technology of Ge surface preparation with chemical etch polishing as final operation. Right column: Ge surfaces prepared by deterministic SPDT technique using FG 350 from Moore Nanotechnology Systems. Surface height profiles showing better flatness in the case of SPDT.

Vacuum chamber for samples



High intense X-ray source with Gallium liquid anode.

Nanostar system (Bruker) with high intense microfocus X-ray source using Montel optics