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 polyolithic 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. 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).

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 mm² 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.

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-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.

The expertise 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.