5.3 The Multitechnique goniometer (GMT)

The MultiTechnique Goniometer GMT is a general purpose 2+2 axis surface diffractometer, well suited to most grazing incidence scattering techniques (GIXS, XRR, GISAXS). It is normally dedicated to samples elaborated ex-situ but it can also accommodate a wide range of sample environments due to the large open space available around the goniometer center. It has been used during the last years for solid/solid, solid/liquid and solid/air surface and interface studies, mostly using X-ray energies between 20 and 30 keV.

As opposed to the INS setup, the experiments taking place on GMT do not usually request lengthy surface preparations ahead of the beamtime. It is therefore located upstream of the INS endstation, sharing a hutch and alternatively using the beam with the µLaue setup while the INS setup is preparing samples or baking out.

Thanks to the large volume accessible at the sample position, the instrument can accommodate a large variety of sample environments, ranging from small enclosures (e.g. electrochemical cells) to a large UHV system with two chambers devoted to in-situ studies of catalytic processes. The goniometer can also handle vibration filtering tables for liquid surface studies, helium cryostats, magnets, and a variety of furnaces. The first µLaue experiments were actually run using the goniometer as a support for both focusing and sample movement elements, while the 2D detector was mounted on the detector arm.

The instrument has been used in the last years mainly for the study of buried interfaces *e.g.* liquid/solid or solid/solid interfaces. We make use of the 20-30 keV energy range of our bending magnet to access the interfaces, going through one side of the interface (*i.e.* one of the phases) over its whole width.

We have automated as much as possible sample changing. For solid/solid interfaces for example, samples are piled up and automatic alignment routines have been developed so as to be able to study series of about 20 samples. Routines for automatic data inversion (*e.g.* reflectivity data) have been developed in parallel.

The instrument has received little evolutions during the last 4 years. Its mechanics is still accurate enough and efforts have been put on developing or replacing the other beamline instruments. Only part of the motors electronics has been upgraded, *e.g.* with the installation of ESRF icepap controllers for detector slits motors.

More recently, we have started to use 2D pixel detectors for diffraction experiments. We use a 5-chip 256*1280 silicon pixel detector that can be mounted in both orientations regarding its long direction (generally along CTR direction, depending on sample orientation). The detector has been used for instance to record diffraction patterns from artificial gratings. Due to their small pixel size, low noise and high counting rates, these detectors are interesting and may speed up the acquisition of reciprocal space maps. Recent reports from SOLEIL have shown for example how to use low-diverging beams and 2D detectors to speed up reflectivity measurements [Mocuta *et al.*, J. Synchrotron Rad. (2018). **25**, 204-213]. However, the poor efficiency of Si pixel detectors limits their usage for the medium high energy experiments. We expect this limitation to be removed with today's availability of CdTe pixel detectors. Tests have already been made and a small size pixel CdTe detector (Maxipix) has been acquired just before the EBS shutdown.

Many of the experiments performed on GMT have a link with applied research subjects. We have worked on the physics of several steps of the SmartCut™ technology developed at the CEA-Grenoble and its spin-off company SOITEC. In particular we investigate the ion implantation, wafer direct bonding and fracture. Other subjects of technological interest have been addressed, like SEI (Solid Electrolyte Interphase) formation at the interface between electrode and electrolyte in Li batteries. Strain (GID, RSM) and size measurements (SAXS, GISAXS) on microelectronics systems patterned using state-of-the-art lithography have also been recently performed to develop the Critical Dimension SAXS (CDSAXS) technique.