3rd International Conference on Tomography of Materials and Structures
Lund, Sweden, 26-30 June 2017, ICTMS2017-122

DANMAX - THE DANISH MATERIAL SCIENCE BEAMLINE AT MAX-IV

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Keywords: x-ray tomography, powder diffraction, in-situ, beamline

Summary: Here we present a short description of the new Danish beamline for material science at the MAX-IV facility. The beamline will perform two types of experiments: a full field imaging (tomography) and a powder diffraction. DanMAX is now under construction, and the first user experiment is expected in 2019.

1. INTRODUCTION

DanMAX will be a world-leading materials science beamline dedicated to in situ and operando experiments on real materials. The beamline is being built at the MAX IV 3 GeV storage ring and operate in the 15-35 keV range. Two principal experimental techniques would be utilized: a full field imaging and a powder X-ray diffraction. DanMAX would start receiving first users in 2019.
DanMAX beamline is a common project between the Swedish party (MAX-IV facility) and three Danish universities (Technical University of Denmark, Aarhus University and University of Copenhagen). Although Danish researches would have priority access, the beamline is open for general user proposal program. Up to 10% of the accelerator time can be used for industrial research.

2. UNDULATOR AND OPTICS

A 3 m long in-vacuum undulator with a magnetic period of 16 mm and a minimum gap of 4 mm will ensure a very bright and well collimated beam over the full energy range. The optics will be very flexible and capable of delivering a beam with a broad-band-pass and very high intensity or a highly monochromatic beam. Both options will deliver beam at the same sample position, thus, minimizing the time spend on alignment.

A high pass 1 mm thick diamond filter (Fig. 1a) will remove most of the heat load on downstream optics by absorbing photons below ~12 keV. A horizontal reflection double-bounce Si (111) monochromator (Fig. 1b) is capable of selecting a highly monochromatic ($\Delta E/E \sim 10^{-4}$) beam with the best wavefront preservation. A B_4C/W multilayer mirror monochromator (Fig. 1c) can be used when a maximum flux is required with larger energy bandwidth (~1%). A set of parabolic compound refractive lenses (Fig. 1d) can be used either for beam collimation or focusing, and the size of the beam at the sample position can be varied from ~1 mm to ~3 µm.

3. END STATION

The beamline will have two instruments in one common end station: a full field imaging and powder X-ray diffraction. The imaging instrument (Fig. 1e) will enable multi-modal, multi-scale analysis of the internal structures of bulk materials by using absorption, phase or diffraction contrast. A versatile tomographic air-baring stage will accommodate a large range of sample environments, and detectors can be placed at virtually any place in the hutch, from few mm up to 14 meters from the sample position, thanks to the robotic arm (Fig. 1h). Three

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imaging geometries will be used for tomography at DanMAX – a parallel beam projection (with approx. 1 µm spatial resolution), an X-ray microscopy mode with compound refractive or Laue multilayer lenses as objectives (expected resolution below 100 nm) and a cone beam projection mode.
Two diffraction instruments (Fig. 1f and g) will utlize both 1D, 2D and energy resolved detectors to perform a wide range of experiments. The arrangement of detectors will be flexible to facilitate both experiments requiring high angular resolution or high resolution in reciprocal space. A smaller robotic arm (Fig. 1i) will be used for automatic sample changing on both, tomographic and diffraction instruments, for maximizing beamline efficiency.

4. VIRTUAL EXPERIMENTS.

Besides the physical beamline a complete virtual model is build in the X-ray ray tracing software McXtrace [mcxtrace.org]. This model will be available on a web server for users to run and test their proposed experiments online before coming to DanMAX to perform the real experiment.
To ensure a fast feedback to the experiments the acquired data will be processed on the fly i.e. automatic integration of 2D PXRD and reconstruction of tomographic data.

5. SAMPLE ENVIRONMENTS

The beamline will strive to operate and continually develop a large range of advanced sample environments. Open standards will be available, both mechanical and software, for fast and easy integration of custom-built sample environments at the beamline.
Metadata from the sample environments will be collected at stored with the primary data for easy reference during the data analysis.

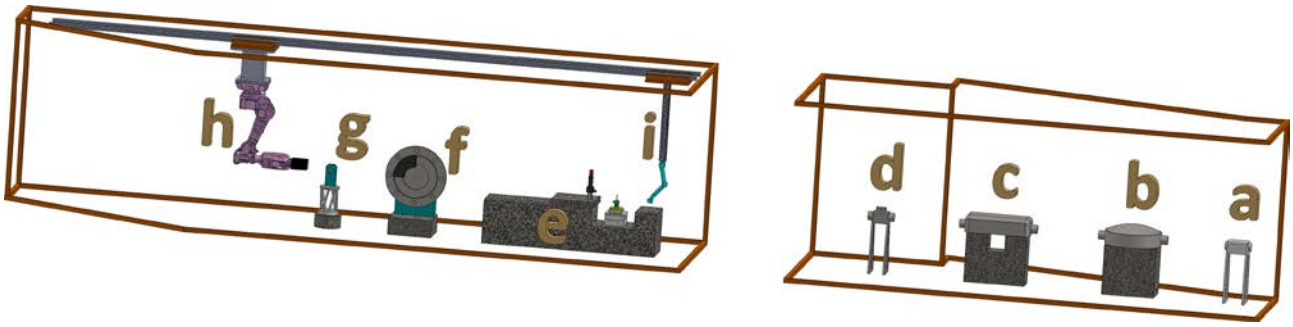

Figure 1: DanMAX schematic layout. Optics hutch: a – high-pass diamond filter, b – double crystal Si (111) monochromator, c – broadband multilayer mirror monochromator, d – beryllium compound refractive lenses transfocator. Experimental hutch: e – imaging (microtomography) instrument, f – high resolution powder diffraction instrument with 1D detector, g – versatile diffraction instrument for bulky sample environment, h – robotic arm with the 2D diffraction or imaging detector, i – small sample changing robot.