

Differential phase contrast – new imaging method for HARWI-II beamline at DESY using hard x-ray grating interferometer

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INTRODUCTION: Phase contrast imaging is a common technique to visualize soft tissue with much higher contrast than the conventional absorption contrast imaging. Differential phase contrast (DPC), developed at PSI, Switzerland, makes use of a hard x-ray grating interferometer and allows for phase contrast imaging with high brilliance synchrotron sources as well as with conventional x-ray tubes. It is recently reported also to provide dark field information that is very sensitive to micro structures like porosity within the materials¹. Here we present the plans to adopt the DPC technique to the HARWI-II materials science beamline², operated by GKSS Research Centre, in cooperation with DESY, Hamburg. This will offer an amount of new applications especially in the field of biomaterials like for example studying corrosion of magnesium as implant material. The excellent results obtained at the ESRF³, France demonstrate the potential of DPC for biomedical studies.

METHODS: Figure 1 shows a schematic of the planned DPC setup for the HARWI-II beamline at the 2nd generation synchrotron source DORIS. The setup will consist of three gratings G0, G1 and G2, a specimen, and a detector. The absorbing grating G0 will be placed directly after the monochromator and will serve as a multiplexed source. The phase grating G1 behind the specimen acts as phase mask and produces periodic phase modulations in the x-ray wave front. Due to the Talbot effect the phase modulation causes a linear periodic fringe pattern in the plane of the second absorbing grating G2 that has the same periodicity as the fringes and acts as analyzer. The grating fabrication process involves photolithography, deep etching into silicon and electroplating of gold.

The grating G1 will be scanned along the transverse direction and for each projection it will yield quantitative images of the specimen's phase shift gradient $d\Phi(x,y)/dx$, the dark field image and the conventional absorption projection.

RESULTS: The DPC setup will be optimized for 28 keV, due to the maximum flux at that energy.

A set of gratings with grating periods $p_0 = 55 \mu\text{m}$, $p_1 = 40 \mu\text{m}$, and $p_2 = 2 \mu\text{m}$ will be produced at PSI in Switzerland. These gratings will be used in the 5th Talbot order with the distances G0 - G1 of 6 m, G1 - G2 of 0.2 m, and 40 m between the source and G0. The spatial resolution of $\sim 15 \mu\text{m}$ will be achieved in phase contrast images.

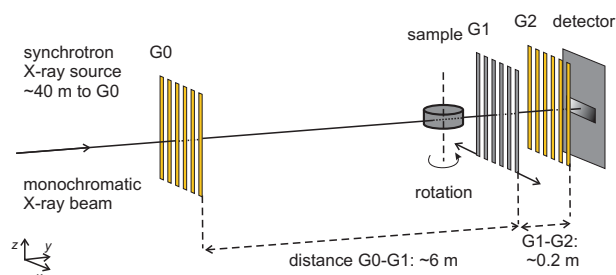


Fig. 1: Schematic of DPC setup for HARWI-II consisting of three gratings G0 (40 m away from source), G1 (6 m from G0.) and G2 (0.2 m from G1), the specimen and the detector.

DISCUSSION & CONCLUSIONS: The reported results on biological samples, the high sensitivity for soft tissue and the stability of the DPC technique using a hard x-ray grating interferometer show its potential for studies in the field of soft tissue.

Adopting this technique for the materials science beamline HARWI-II would expand the range of applications to the field of materials science, especially of biomaterials. The advantages of the synchrotron source with a large field size (70 mm (h) x 10 mm (v)) and monochromatic x-rays will allow for analysing centimetre sized objects.

REFERENCES: ¹F. Pfeiffer et al. (2008) *Hard-X-ray dark-field imaging using a grating interferometer*, Nature Materials **7**, pp. 134-137. ²F. Beckmann et al. (2006) *New developments for synchrotron-radiation based microtomography at DESY*, Proc. of SPIE Vol. 6318, 631810. ³F. Pfeiffer et al. (2007) *High-resolution brain tumor visualization using three-dimensional x-ray phase contrast tomography*, Phys. Med. Biol. **52**, pp. 6923-6930.