Novel Microstructured X-ray Source Designed for Grating-Based Phase Contrast Imaging

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X-ray phase contrast imaging (XPCI) is one of the most exciting new methods that has emerged in x-ray physics over recent years. The technique enables simultaneous access to the measurement of three distinct x-ray phenomena: absorption, phase, and scatter (darkfield) imaging [1]. Absorption contrast is the most well-known and has been traditionally used in x-ray imaging applications (e.g. dental x-ray exams, micro computed tomography, etc). Phase contrast, derived from the refractive index of materials, offers compositional information and orders of magnitude higher sensitivity for imaging low Z materials in comparison to absorption-based contrast [2], and interest in darkfield imaging has recently grown rapidly due to its potential for uncovering sub-resolution feature information [3].

The grating-based Talbot-Lau interferometry approach is considered the most promising laboratory method and involves the use of gratings to produce interference patterns from which the three contrast mechanisms can be determined. One major problem, however, has been the low throughput and efficiency of such systems stemming from the brightness limitations of laboratory x-ray sources and the use of a grating placed near the source (the “G0” source grating).

We present a major innovation in x-ray sources with an optimized design for grating-based x-ray imaging. The patented Sigray FAAST-Phase™ source features an anode comprised of arrays of metal (e.g. Cu, W) microstructures x-ray emitters embedded in a diamond substrate, which enables highly localized and large thermal gradients to passively and rapidly cool the metal microstructures as x-rays and heat are generated under the bombardment of electrons. This enables substantially higher brightness for rapid phase contrast data acquisition, with throughput gains of ~4X over the current approaches of using a rotating anode in combination with a source grating. Moreover, the source produces an optimal Talbot interference pattern, featuring bright anti-nodes and dark nodes for high contrast preservation and large fringe pitch that reduces requirements on downstream components, such as the detector and the detector grating.

Future potential developments of the x-ray source and Talbot-Lau system system design will be discussed.

[1] N Bevins, et al. “Multicontrast x-ray computed tomography imaging using Talbot-Lau interferometry without phase stepping.” *Medical Physics* (2012).
[2] A Momose. “Recent advances in x-ray phase imaging,” *Japanese Journal of Applied Physics* 44:9A (2005): 6355-6367.
[3] V Revol, et al. “Sub-pixel porosity revealed by x-ray scatter dark field imaging.” *Journal of Applied Physics* 110 (2011).
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