

Phase-contrast imaging at 100 keV

Grating interferometry on a conventional X-ray tube

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INTRODUCTION

Grating interferometry [2] can perform phase-contrast imaging on conventional X-ray sources [3]. This technique is sensitive to attenuation, refraction and scattering of the radiation. Imaging at energies between 80 keV and 150 keV is particularly relevant for medical computed tomography and material science. Here we show the design of a Talbot-Lau interferometer with edge-on illumination and a target energy of 100 keV. The edge-on approach can achieve the large aspect ratio needed to block the high-energy radiation in the absorption gratings with the currently available fabrication technology.

ASPECT RATIO AND EDGE-ON ILLUMINATION

The aspect ratio of a grating with pitch p and depth h is given by

$$R = \frac{2h}{p}.$$

This quantity is critical since a small pitch is needed for high sensitivities, and a large depth is required to effectively block the high-energy radiation. Thus, R increases with the target energy of the interferometer. The aspect ratios for a high-energy system (at least 120) are not available with current technologies [1], but edge-on illumination can be used to overcome this limitation.

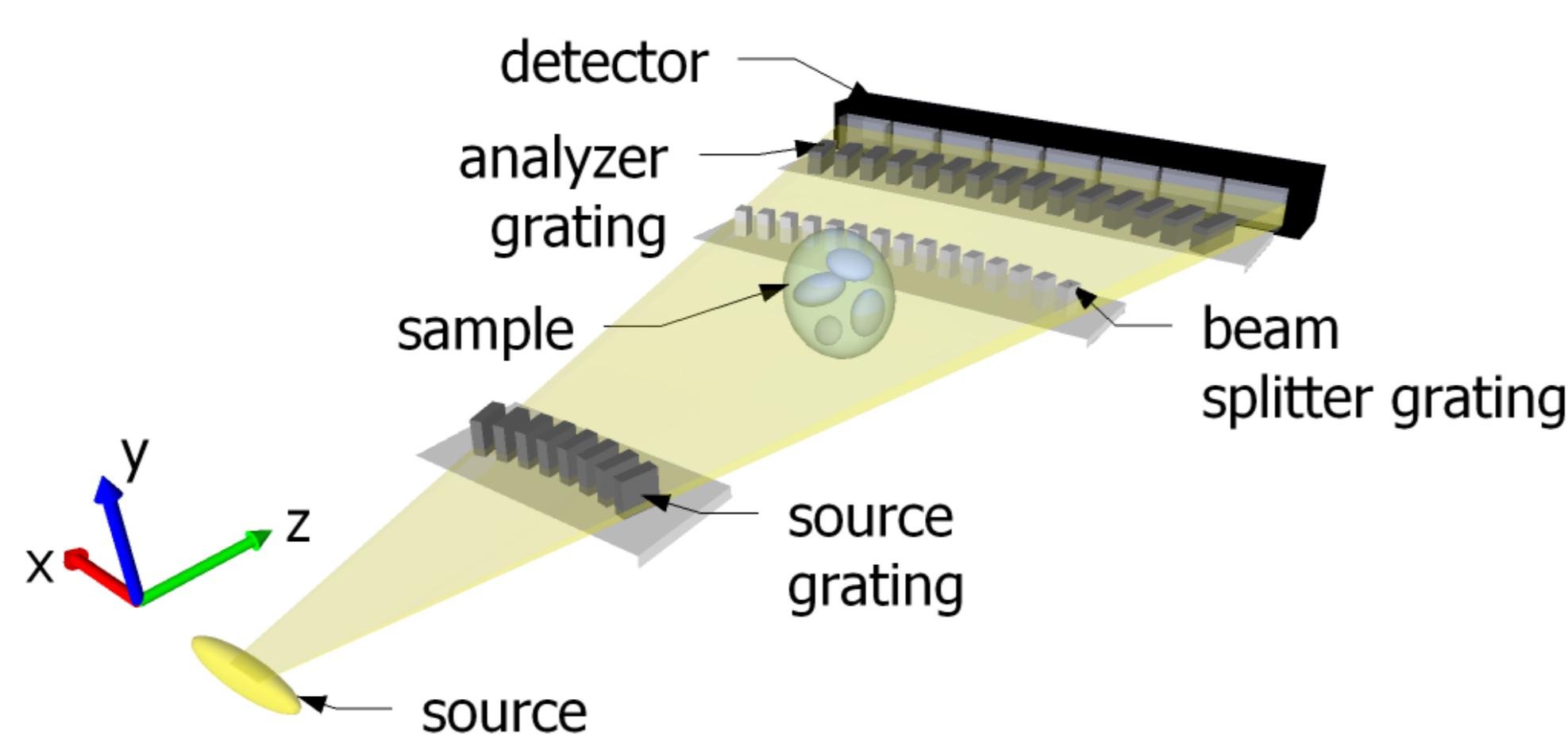


FIGURE 1: schematic of the grating interferometer with edge-on illumination. The grating structures are circularly aligned in order to match the fan beam.

In the edge-on configuration, the object is scanned along the vertical y direction as one line at a time can be acquired.

GRATING DESIGN

The gratings were manufactured by Microworks GmbH, Germany, using a LIGA process. Gold was used for the absorption and the beam splitter gratings.

intergrating distance	15.8 cm
total length	54 cm
Talbot order	$d = p/8\lambda$
pitch	$p = 2.8 \mu\text{m}$

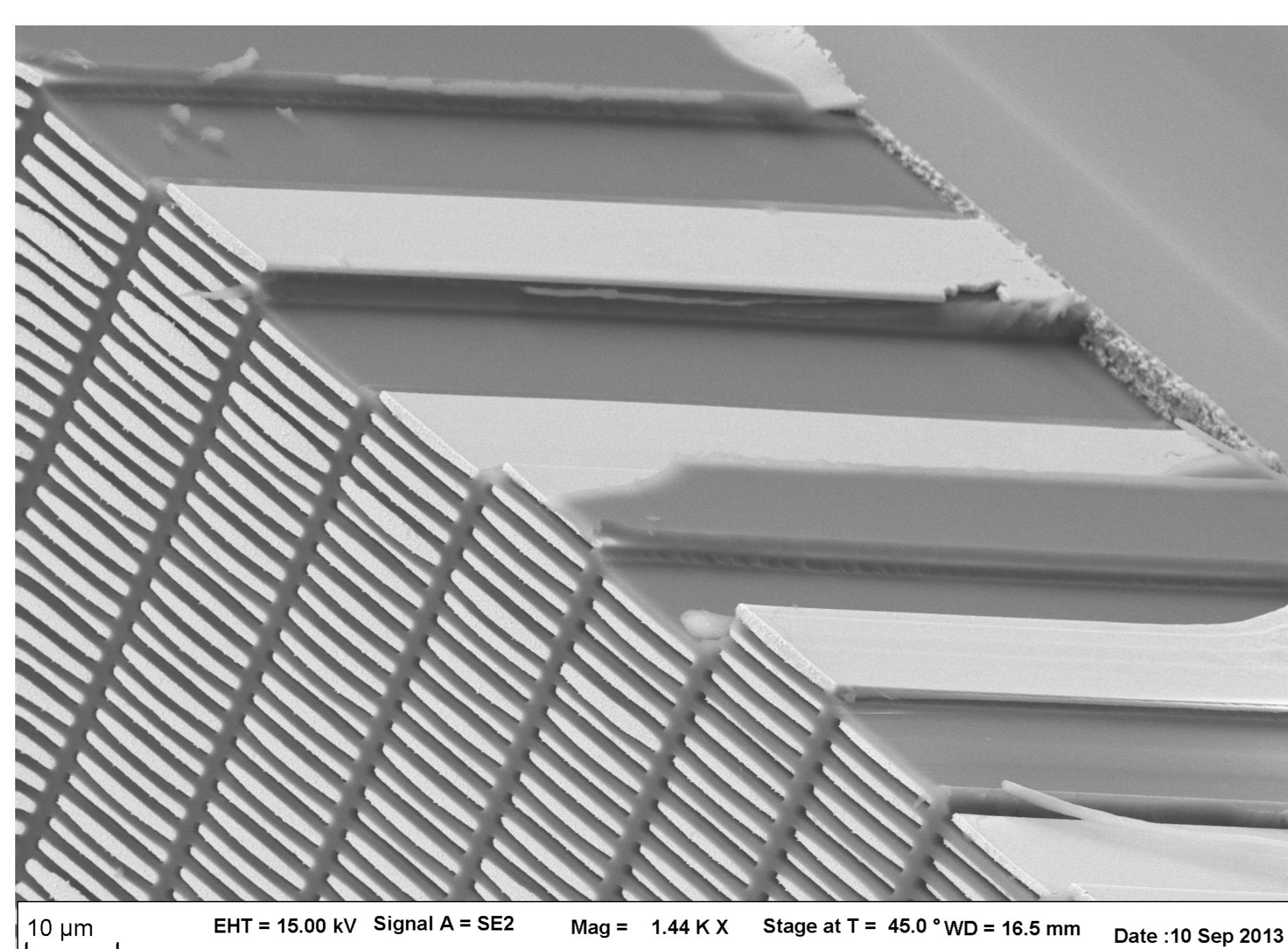


FIGURE 2: scanning electron microscope image of the grating structures.

RESULTS

The setup was successfully operated, although with a rather low average visibility ($\sim 5\%$) caused by the low quality of the gratings. The first images show the three complementary contrasts retrieved from the phase-stepping procedure [4].

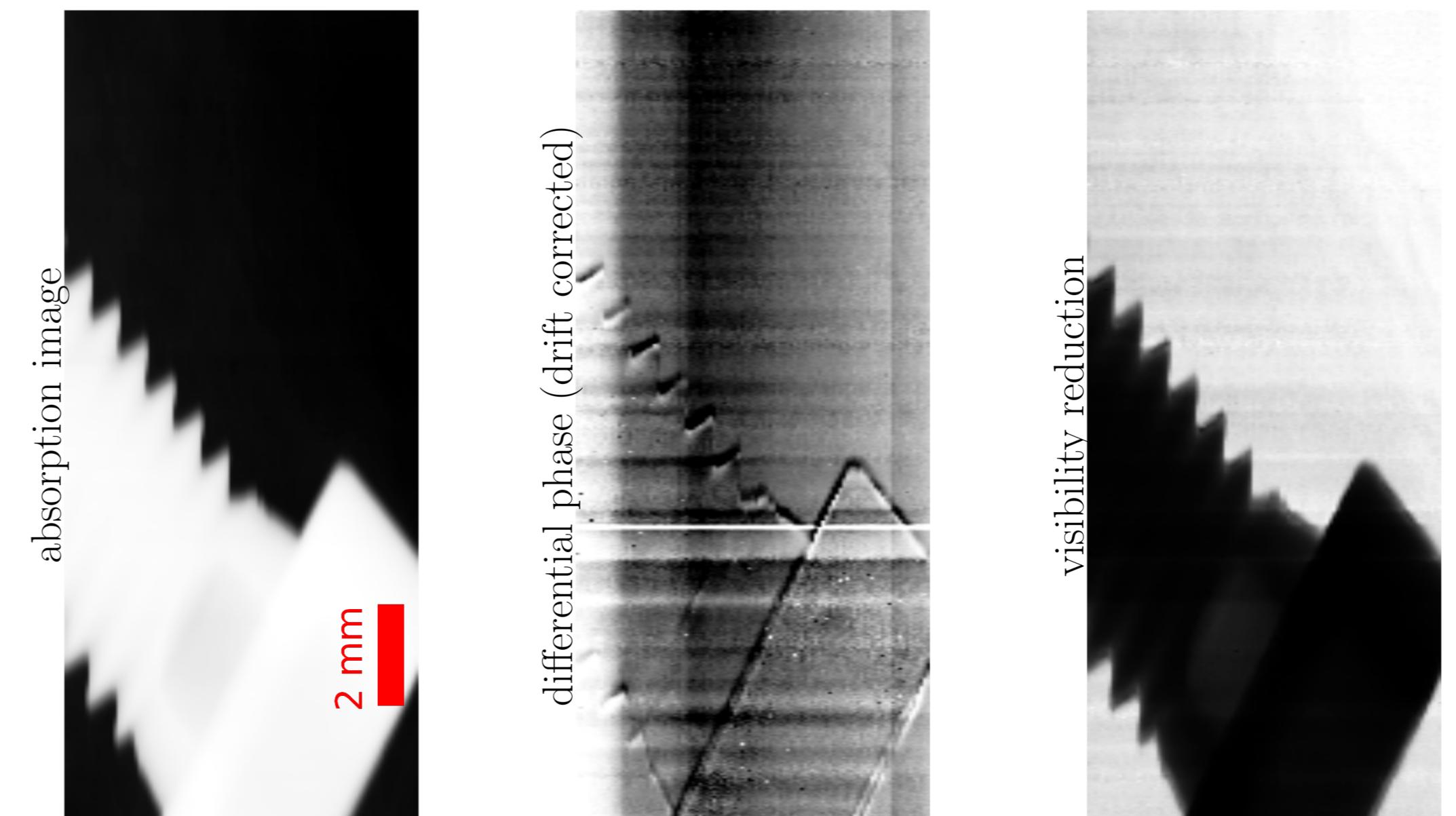


FIGURE 3: absorption, differential phase and dark-field image of a metal screw scanned in 100 μm steps.

The exposure time has to be very long (24 phase steps \times 15 s per line) in order to reduce the noise given by the low visibility.

OUTLOOK

- This setup demonstrates the feasibility of grating interferometry and the availability of the three complementary contrast mechanisms at high energies and compact setups.
- The technique is very promising for applications on conventional sources in the diagnostic energy range between 80 keV and 150 keV, relevant for material science and medical imaging.
- Improvements in the fabrication of the gratings will substantially decrease the exposure time as the visibility increases.

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ACKNOWLEDGEMENTS

We thank Gordan Mikuljan and István Mohácsi from PSI for the work on the mechanical design and the SEM images respectively, Joachim Schulz and Marco Walter from Microworks GmbH, Germany, for the competent support on grating design issues, Christian Kottler and Vincent Revol from Centre Suisse d'Electronique et de Microtechnique (CSEM), Switzerland for the fruitful discussions on the design of the system. This work has been partially supported by the Competence Centre for Materials Science and Technology (CCMX) of the ETH-Board, Project Nr. 61 and by the ERC Grant ERC-2012-StG 310005-PhaseX.