Development of X-ray phase imaging method using a compact high-brightness X-ray generator

Sub-theme: Evaluation of the Gratings for a Talbot-Lau Interferometer

Tohoku University, IMRAM

Margie P. Olbinado, Atsushi Momose

Purpose of this work

To determine the **optimum X-ray energy** for the grating interferometer by measuring the X-ray energy at which there is **maximum fringe visibility**

To be able to give a recommendation for the X-ray source energy setting for X-ray phase imaging using this grating interferometer

Background

The optimum energy is for which the phase grating gives $\frac{\pi}{2}$ X-ray phase shift:

$$\phi(E) = \frac{2\pi}{\lambda}\delta(E)h_1$$

optimum energy

❑ Grating parameters for a Talbot-Lau interferometer ***E* = 30 keV** was designed and acquired

Grating Type	**Source Grating, G0**	**Phase Grating, G1** **π/2 phase shift at 30 keV**	**Analyzer Grating, G2**
Material	Au	Ni	Au
Period (μm)	6.82	3.57	7.49
Structure Height (μm)	Design: 70 Measured: >70 +-10%	Design: 5.23 Measured: 5.34 +- 0.35	Design: 100 Measured: 103

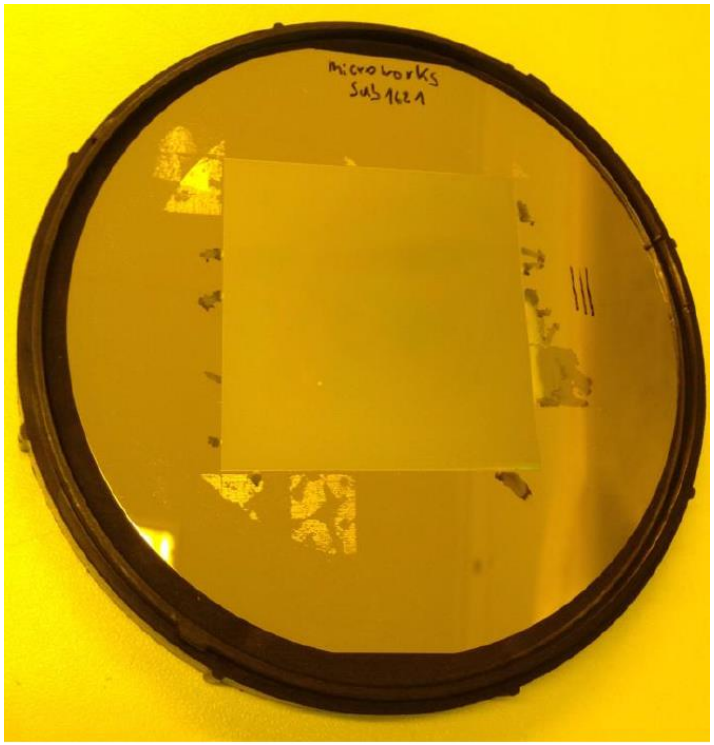
The maximum moiré fringe visibility was observed at 26 keV. An incorrect grating height was suspected and a replacement grating was requested from Microworks (Germany).

Replacement Phase Grating

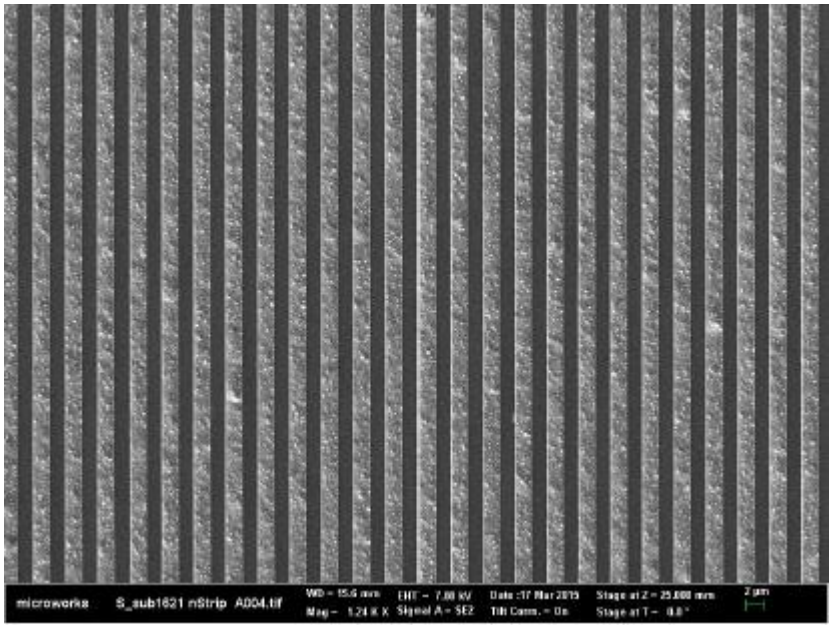
Specifications:

Grating period	3,57 µm
Grating height specified	Nickel height 5.23µm
Mask for exposure	1266_00_A0 Los Nr. 05285
Substrate type	200 µm Si, CrAu seed layer

Actual parameters of the grating:	
Grating qualtiy	Good
Ni height	5,18 +- 0.27 µm
Grating DC	0,51+/- 0,03



SEM Image



Overview of this report

1. Measurement of the Moiré fringe visibility using the replacement phase grating for a design energy 30 keV and comparison with the old phase grating.

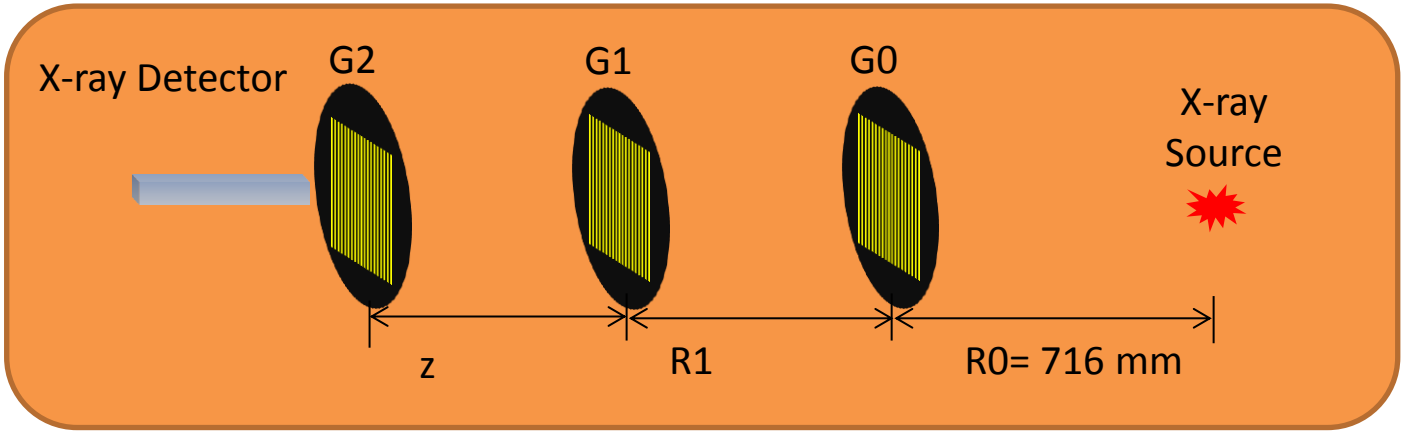
2. Measurement of the Moiré fringe visibility using the replacement grating when the design energy was changed to 25 keV
   - ❑ Comparison with simulation

3. Conclusions and Recommendation

Experiment Parameters

X-ray Source	Hamamatsu Photonics Micro-focus Source (Large focus mode) Source size: 300 µm Tube Voltage: 50 kV Tube Current: 300 µA
X-ray Detector	Energy-resolving Detector: AMPTEK CdTe diode Pinhole: 1mm, Pinhole thickness: 1mm W Area Detector: 40 µm GOS scintillator connected to CCD Camera via fiber coupling (Spectral Instruments)

X-ray Talbot-Lau Interferometer Set-up

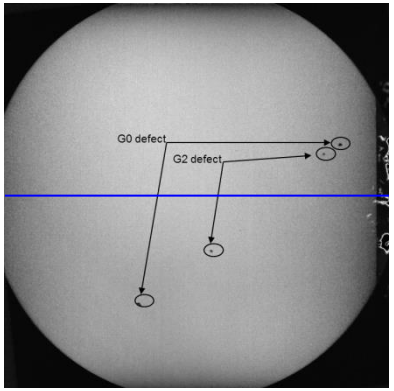


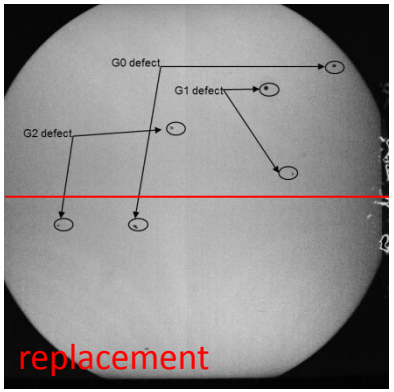
Moiré fringe visibility via fringe scanning. G2 was moved across one period d2 in steps of d2/5
Detector was located at the center of G2.

Results: Moiré Fringe Visibility

1. A Comparison between old and replacement grating

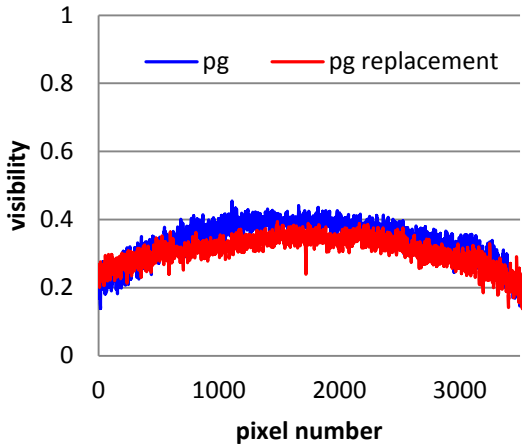
5 step fringe scan:
1 minute/ step



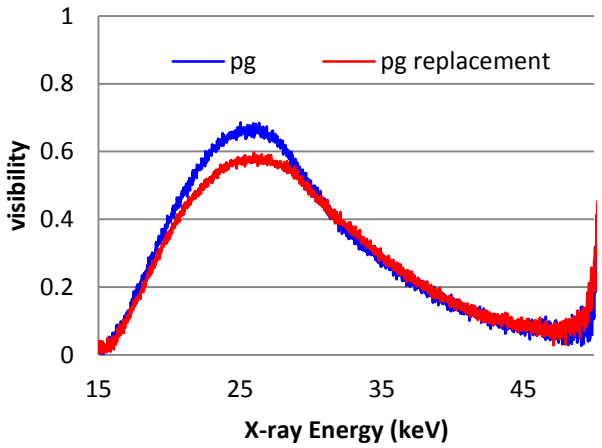


Gray scale: [0, 0.5]

Visibility line profile

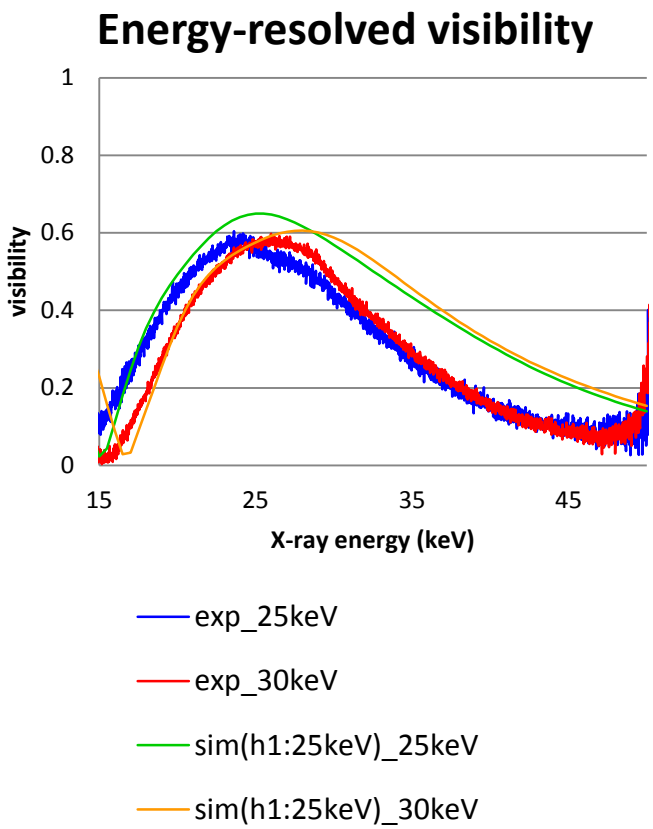


Energy-resolved Visibility



The energy-resolved visibility measurement shows that the maximum visibility is at 26 keV for both phase gratings.

Results: Moiré fringe Visibility
2. When the design energy was changed to 25keV



The position of the maximum visibility were:
26 keV for design energy 30 keV
24 keV for design energy 25 keV

This shift is confirmed by simulation.
(G1 was assumed to have a $\pi/2$ shift for 25 keV.)
27 keV for design energy 30 keV
25 keV for design energy 25 keV

The measured visibility at higher energies was lower due to the bridge structures in G2.

The Talbot- Lau interferometer is recommended for operation at an optimum energy of 25 keV.

Conclusion and Recommendation

The position of the maximum visibility for the replacement grating was similar to that of the old phase grating.

The Talbot- Lau interferometer using this phase grating is recommended for operation at a design energy of 25 keV.