A.5. Experimental observation and phase realization of Talbot array illumination for 2-Dimensional phase grating

X-ray phase contrast imaging (XPCI) has received considerable attention because of the presence of high contrast for weakly absorbing objects like polymer, fiber, soft tissue etc. Among the different techniques for achieving phase contrast image, the Talbot interferometric technique is a promising one due to its various advantages. When a grating is illuminated by monochromatic light, the Fresnel diffraction of periodic wavefront yields self imaging effect. This self imaging effect is known as Talbot effect and it is formed at a Talbot distance (Z_T) $2d^2/\lambda$ (where, d and λ are the grating period and wavelength of light respectively). Talbot interferometer consists of phase grating, analyzer grating and an image detector. Now-a-days, the detection of phase using this method is carried out by phase stepping of analyzer grating at Talbot distance.

In the case of phase grating with specific duty cycle and phase step, the array of bright spot is formed by means of interference of the diffracted wave at certain fractional Talbot distance, called Talbot array illuminations (TAI's). Therefore, the TAI's at these fractional Talbot plane is purely due to phase, which bear a strong resemblance to the spatial structure of the phase grating. We propose an alternate improved approach to experimentally decode the phase at fractional Talbot distance and have been used for phase contrast imaging. In this work, we have fabricated the two dimension (2D) phase grating on glass substrate with large uniform area by deep reactive ion etching (DRIE) system at Synchrotrons Utilization Section. The periodicity of the fabricated grating is 85 μm, duty cycle 0.71 and phase depth is π shown in Fig. A.5.1.

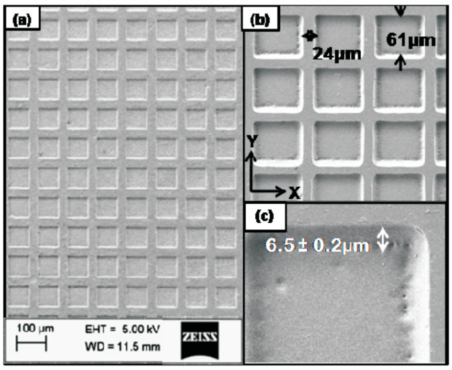

Fig. A.5.1: (a) SEM view of DRIE fabricated 2-dimensional grating, (b) Magnified, (c) Etch depth is ~ 6.5μm.

The experimental observation of TAI's and its detection of phase were performed at Laser Plasma Section. Coherent source in visible region, He-Ne laser (λ=632.8 nm) was used as a light source in this experiment (Fig.A.5.2).

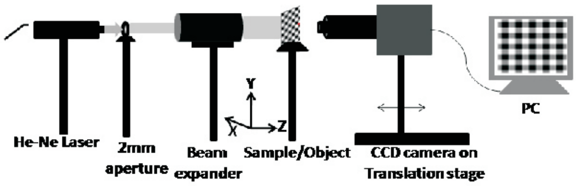

Fig. A.5.2: Schematic of the experimental set-up for observation of Talbot Array Illuminations.

The multilevel TAI's as well as phase distributions over a single period are shown in *Fig. A.5.3*. In order to explain the observed interference pattern along propagation direction, we have solved the Fresnel wave equation numerically. *Fig. A.5.3(a)* shows the experimental TAI's at first fractional Talbot distance ($Z_T/8$) i.e. 2.81±0.01 mm. The numerically generated TAI' is shown in *Fig. A.5.3(b)*. The experimental as well as numerically found normalized intensity distributions over the single period are plotted in *Fig. A.5.3(c)*. At each plane within a period four sublevels of intensities are formed. Each sublevel of intensity corresponds to distinct spatial harmonic image. Amongst the sub-regions few are marked, such as (1,0) x-direction harmonic image, (0,1) y-direction harmonic image and (0,0) central harmonic image. *Fig. A.5.3(d)* shows the numerically found four level phase encoder with phase interval of d/4 at $Z_T/8$.

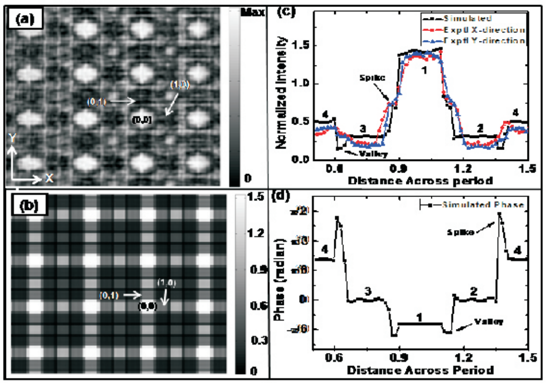

Fig. A.5.3: (a) Experimentally observed, (b) numerically generated TAI's, (c) Intensity profiles, (d) Numerically found phase distribution

We have thus experimentally decoded the phase at fractional Talbot plane without any phase stepping in a single shot exposure. This could be an important aspect of coherent XPCI that could reduce the radiation dose on object especially in medical imaging. For more details please refer to *Mondal et al., J. Appl.Phys.120, 153103 (2016).*

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