Electron beam lithography for the realization of electron beam vortices with large topological charge (L=1000ħ)

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Electron vortex beams (EVBs) are an appealing topic, both in fundamental science and for practical applications in electron microscopy [1, 2]. Some of the most promising applications require beams that have large orbital angular momentum (OAM) [2, 3, 4]. Here, we demonstrate the largest (L=1000 ħ) high quality EVB by using electron beam lithography (EBL) to fabricate a phase hologram. EBL provides superior fabrication quality and a larger number of addressable points when compared with focused ion beam (FIB) milling. We measure the OAM of the generated EVB through propagation after a hard aperture cut [5]. Comparisons with simulations confirm an average OAM of (960±120)ħ , which is consistent with the intended value.
A clear improvement when compared with a FIB-nanofabricated hologram is demonstrated in terms of 1) the maximum OAM that can be reached; 2) the minimum feature size (33 nm in the present study); 3) the improved uniformity of the frequency response; 4) the better suppression of higher order diffraction due to a nearly perfect rectangular groove profile.
We believe that EBL will be the fabrication technique of choice for most new diffractive optics with electrons in the future, permitting more complex holograms and new applications in material science.

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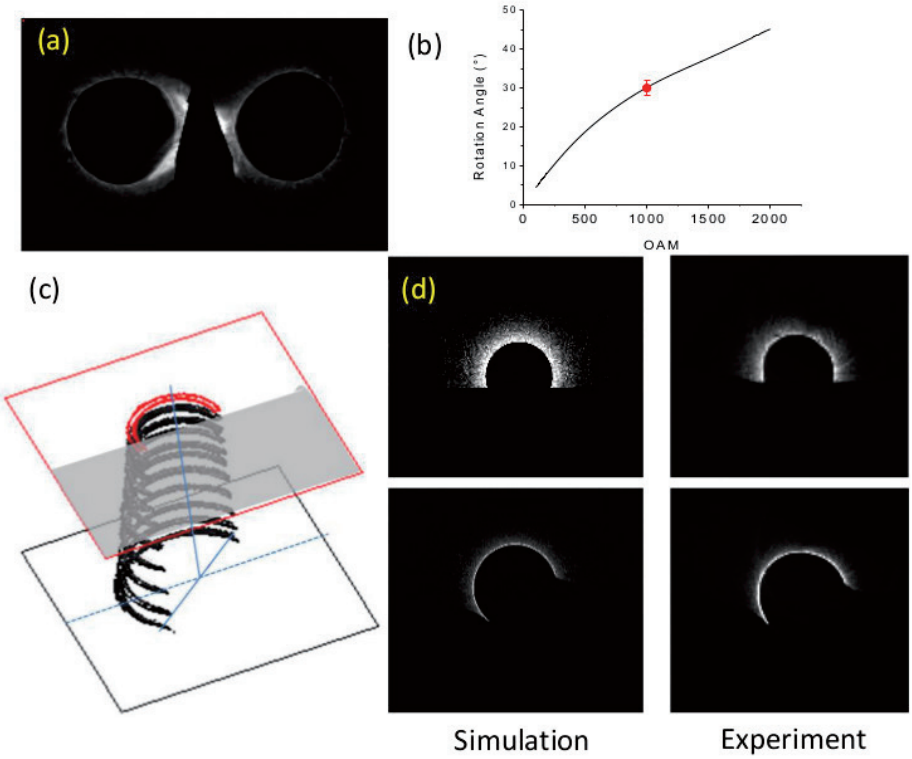

Fig 1 a) Experimental image of the full diffraction of the hologram described in the text, recorded close to focus. A beam stopper is used to blank the transmitted beam. b) Plot of the expected rotation angle as a function of orbital angular momentum. The dot shows our experimental measurement. c) Schematic diagram of the knife edge experiment used to measure the beam rotation. d) Experimental results and simulations for □=1000 before and after propagation.