PB12

CHALLENGES AND OPPORTUNITIES FOR GENERATING STRUCTURED ELECTRON WAVES USING NANOFABRICATED DIFFRACTON HOLOGRAMS

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Abstract

Six years after the first reports of sculpting free electrons into vortex states [1, 2], structured electron waves have now been generated successfully using different approaches and have led to a variety of applications in electron microscopy and spectroscopy, as well as to studies of other exotic quantum effects [3]. The use of holographic diffractive optics, which usually relies on the fabrication of nanoscale diffraction holograms using approaches such as focused ion beam milling, is the most popular method for such experiments due to its high fidelity and universal applicability. However, new requests for shaped electron beams require the solution of challenging technical problems, including:

a) For isolated diffracted beams, the primary grating period must be decreased and can reach the present resolution limit of focused ion beam milling;
b) In order to achieve higher intensity in a desired order, a sawtooth groove profile can be used to maximize diffraction efficiency [4, 5] while a perfectly rectangular groove can be used to achieve reasonable efficiency with less effort;
c) For atomic-scale structured beams, increasing the numerical aperture is beneficial but requires extreme instrumental stability over a large hologram area.

Here, we demonstrate a new fabrication protocol based on electron beam lithography [6], which can be used to overcome these limitations. We also explore possibilities to extend the lifetime of holograms with less contamination and charge buildup.

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