Low-NA focused vortex beam lithography for below 100-nm feature size at 405 nm illumination

Myun-Sik Kim[1], Toralf Scharf[2], Hans Peter Herzig[2], and Reinhard Voelkel[1]

[1] *SUSS MicroOptics SA, Jaquet-Droz 7, CH-2000 Neuchâtel, Switzerland*
[2] *Optics & Photonics Technology Laboratory, Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland*

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1. **100-words summary for web publication**

We report on the fabrication of particular structures of sub-100-nm size by using direct-write laser lithography at 405-nm wavelength. A doughnut-shape spot, generated by a low-NA (NA=0.2) focusing of an azimuthally polarized incidence, leads to a central dark region, *i.e.*, optical vortex. When such doughnut-shape beams expose the positive photoresist, well-isolated nano-cylinders are formed. Decomposition of the doughnut beam leads to a two-half-lobes spot that can produce line structures by linear scanning. This is a fast and inexpensive way to fabricate well-isolated nano-solid-immersion-lenses or plasmonic nano-waveguides compared to other nano-fabrication methods, such as, electron beam lithography.

2. **250-words abstract**

There are varieties of novel methods, which demonstrate the super-resolution. For instance, an optically trapped sub-micron dielectric sphere serves as a near-field focusing lens to directly write patterns of ~100 nm in liquid, and accelerated metallic nanoparticles by optical force form a stamp on the substrate, coined optical force stamping lithography. Two-photon absorption lithography is another good example of super-resolution techniques for 100-nm target. Other breakthrough to achieve sub-100-nm pattern size is using two beams: for initiation and deactivation of polymerization with one color or with two colors and for absorbance modulation. Generally, such two-beam techniques rely on doughnut-shape spots, whose tiny dark center is a key feature to achieve such a small size. Here, we propose a new method to fabricate well-isolated single nano-structures using this doughnut-shape vortex beam but a single beam illumination is applied. Regardless of the NA, focusing of azimuthal polarization always assures the dark center while the radial polarization is often used to create a bright center by a high NA. When such vortex beams at λ=405 nm expose the positive photoresist, nano-cylinder are formed in the center of the circular exposed area. A decomposition of the doughnut beam leads to the two-half-lobes spot and the linear scanning of the decomposed spot produces nano-size line patterns. This is a fast and inexpensive way to fabricate well-isolated nano-solid-immersion-lenses or plasmonic nano-waveguides compared to other nano-fabrication methods, such as, electron beam lithography.

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