3D direct laser lithography on large-format complex surfaces

Since it plays a key role in micro and nano fabrication in a wide range of applications, photolithography is extremely important for modern industry. While lithographic patterning is usually performed on flat substrates (e.g. computer chips), there are numerous applications where circuits or circuit-like structures are fabricated on curved surfaces (e.g. curved waveguides, micro-optics or flexible electronics). To fabricate these devices, industry needs to use a resist mask to cover selected areas during subsequent etching, deposition or implantation processes. Traditional photomask-based lithography cannot, however, be used with highly curved substrates. Therefore, resist masks need to be made for reproducible free-form structures on curved surfaces, which poses a particular challenge.

3D lithography using a five-axis system

As a new solution for photomask-free lithography on complexly formed surfaces, a 3D direct laser lithography system has been set up at Fraunhofer ILT. As it has five axes, this system allows the laser beam generated by a UV laser diode to be precisely aligned perpendicular to the curved surface during the entire exposure process. In addition, the institute has integrated a spray coating unit into the system to produce a homogeneous resist layer on complex substrates. Furthermore, it installed a camera recognition unit to enable precise substrate-mask alignment for successive photolithographic steps.

Fabrication of three-dimensional optoelectronic components

This 3D direct laser lithography system has made it possible to produce homogeneous resist layers with less than five percent resist thickness variation on large-format, highly curved surfaces and to write structures with a resolution of 5 µm with high edge quality. In addition, the optical overlay control reaches an accuracy of less than 5 µm. These innovations constitute an important step towards the industrial production of three-dimensional optoelectronic components.

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1 Metal structure on 100 mm lens with 103 mm radius of curvature.
2 Resist mask created on 1-inch lens with 23 mm radius of curvature..

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