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Pioneering 3D photonic integrated circuits

LASER INSCRIBED 3D WAVEGUIDES AND MICROSTRUCTURES IN GLASS

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As a technique to manufacture waveguides and micromachined optical structures in glass, laser inscription may not be as well-established as photolithography, but it offers advantages that align with the needs of optical transceiver manufacturers.

Described as the 'the engine that has powered the semiconductor revolution', photolithography is an essential manufacturing process for building complex integrated circuits. However, photolithography comes at a high cost in terms of both price and complexity.

An alternative technique to generate waveguides and micromachined structures in glass is laser inscription. Much simpler in regard to the amount of equipment needed and the number of process steps necessary, laser inscription only requires one laser processing step for fabricating waveguides. For micromachining, two steps are required, consisting of one laser processing step followed by a wet chemical etch. Moreover, processing is carried out on a machine with a footprint of approximately 2.5m^2, occupying a fraction of the cleanroom floor space expensive photolithography equipment takes up. Yet the most important advantage laser inscription has over traditional techniques is that it enables components to be engineered in three dimensions, providing greater freedom and flexibility in design, and opening up new possibilities for novel configurations.

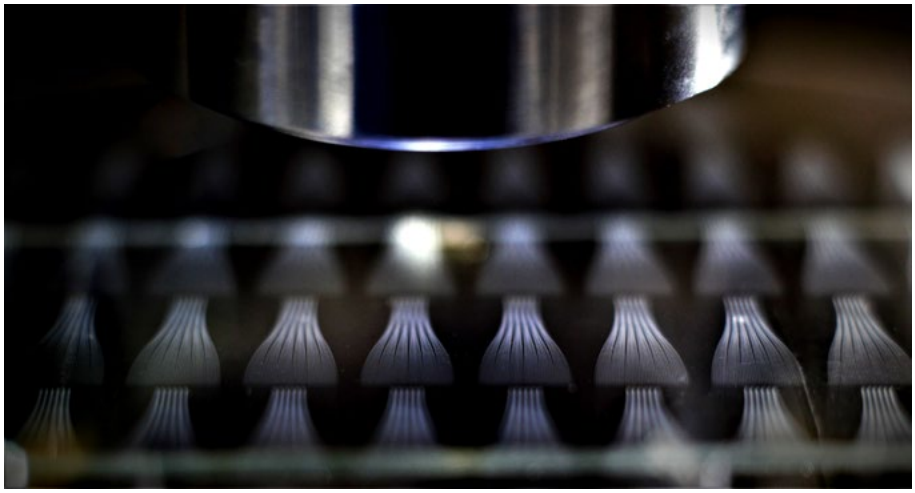
Wafer-scale laser-inscribed optical structures

Optoscribe has developed an ultra-short pulse laser system to directly modify and manipulate the structure of glass. A single laser beam produces ultrashort pulses with high peak powers, tightly focused inside the bulk of the glass. At this focal point, non-linear light absorption generates a permanent, local structural change. This structural change can manifest in many different ways, but the two key modalities Optoscribe deploys to engineer optical structures are a refractive index change and an etch rate enhancement.

The refractive index change is used to create waveguides in three dimensions inside the bulk of the glass, while the etch rate enhancement (of between 500 and 1000 times that of non-irradiated glass) is used to create physical 3D microstructures in the glass. To complete the creation of the physical microstructures, the glass is then subject to a wet chemical etch that preferentially etches away those areas that have been irradiated by the laser, while the remainder of the glass remains unaffected.

3D photonic integrated circuits

Using a standard off-the-shelf laser and borosilicate glass well suited to photonic integration, the innovative aspects of this method lie in the low latency optical system and bespoke software that controls and automates the entire component manufacture process from design through layout to fabrication.



In Optoscribe's state-of-the-art manufacturing facility, waveguide fabrication is both rapid and accurate, with the system tightly controlling cross section, size and shape to provide very well-defined waveguide polarization behavior and a wide library of standard subcomponents, including Y splitters, directional couplers, multimode interference (MMI) couplers and slab couplers. Meanwhile, high precision optical structures such as V-grooves for passive fiber alignment, total internal reflection (TIR) mirrors for light turning and other micro-optic assets can be fabricated via the etch rate enhancement technique.

As these two different types of structures are created during the same laser process, excellent co-alignment between waveguides and microstructures can be achieved, allowing complex 3D photonic integrated circuits to be realized in a fast, simple and affordable process. Such compact monolithic glass chips are ideal for integration into next-generation transceivers.

About Optoscribe

Formed in 2010, Optoscribe uses its innovative laser direct write technology to manufacture 3D glass-based integrated photonic circuits for the telecommunications and data communications markets. These monolithic optical products are primarily used by high volume optical transceiver manufacturers. Optoscribe photonic integrated circuits are helping transceiver manufacturers cost reduce and automate their existing transceiver products as well as simplifying the move to SiPh platforms. The company is located in Livingston, UK and recently opened a state-of-the-art manufacturing facility.

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