FABULOUS

FABrication of 3D metasurfaces to enable the next generation of high efficiency optical products

Enabling technology for micro-fabrication

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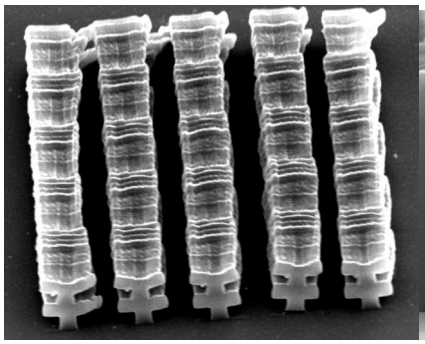
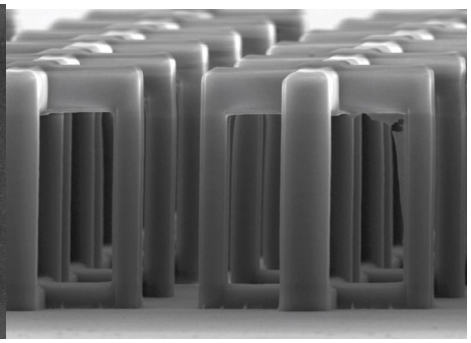
The FABulous research teams at IMTA, FORTH, AIMEN and HIMT are currently working to develop and test novel multi-photon lithographic processes that can produce nano-metric fully 3D structures at high plot rates.

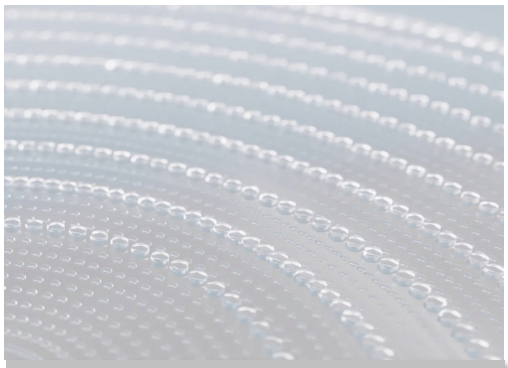
Reaching beyond the state of the art speeds comes with technical challenges that FABulous has been working to resolve. These include, the handling of proximity effects and the prevention of out of plane polymerisation hot spots.

The FABulous team are utilising two complimentary approaches to deal with these issues. The first method involves massively parallelised lithographic printing which has been shown to enable writing of up to millions of voxels per exposure while reducing 3D proximity effects, when applied with an imaged SLM and an ultra-sensitive resist. The second method uses a technique called holographic layer by layer 3D printing, which uses spatial temporal pulse shaping to further reduce or completely remove undesired out-of-plane polymerisation.

Right now, these methods are being tested and optimised for the FABulous applications, with early results showing great promise as can be seen below.







The Project

FABulous will develop an industrial surface 'coating' technology that exploits breakthroughs in multiphoton lithography and process modelling to manufacture high resolution 3D metasurfaces at a throughput viable for series production.

These metasurfaces will be capable of manipulating light with unprecedented flexibility and will open the possibility of designing and manufacturing smaller, lighter, and more environmentally friendly products, through the replacement of bulky components and/or the chemical coatings currently used to enhance the efficiency and performance of optical products.

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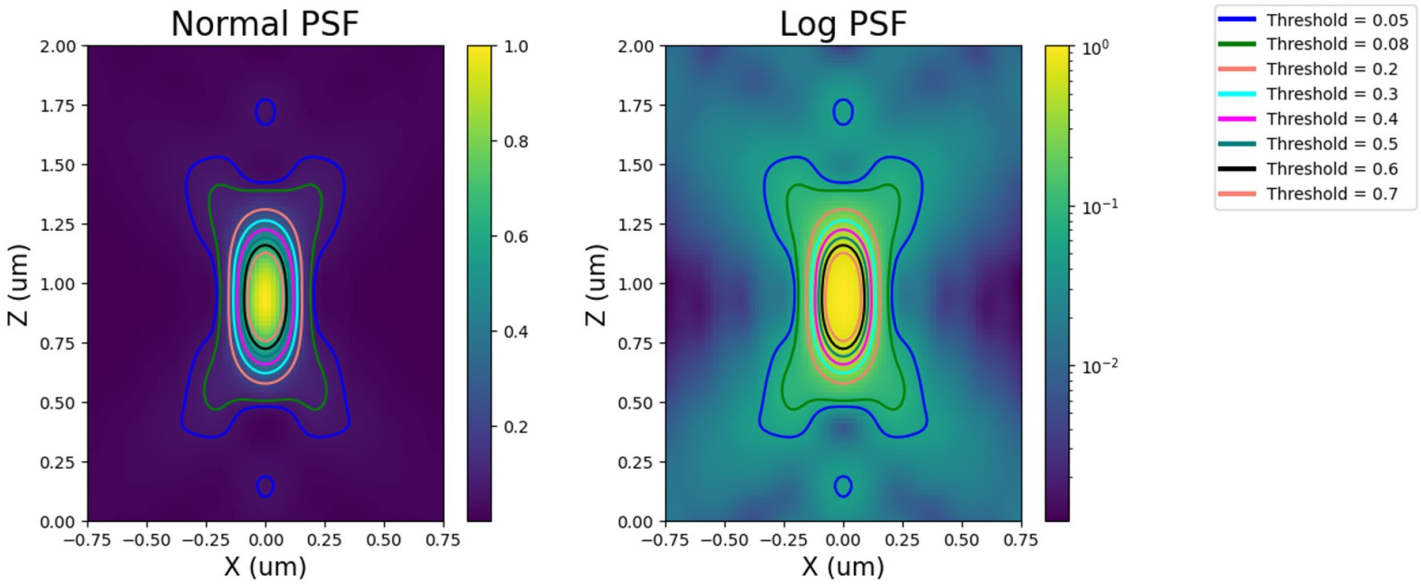
Process optimisation and modelling

Achievement of the FABulous objectives will only be possible through a combination of design, process modelling and technology co-optimisation.

Fabulous Partner IISB is working to develop physical models for optical proximity correction (OPC) to improve the fidelity and resolution of the FABulous direct write process and enable faster printing of 3D surface components.

Phenomenological modelling of the FABulous write process has already demonstrated the potential of using pre-compensation of proximity effects to improve the pattern fidelity and to enable faster writing speeds. Recent work has focussed on understanding pattern formation during the parallelized fabrication process when employing a spatial light modulator (SLM) and an ultrasensitive triplet-triplet annihilation (TTA) resist. The modelling involved considering the experimental setup of the SLM at IMTA. The purpose was to align the simulated outcomes with the experimental results as shown in the figure on the right.



Development of new design tools

Commercial application of the FABulous solutions requires the development of methods and tools that connect system level design with metasurface design so that the resulting product can fully exploit the unique functions that the metasurface can provide.

FABulous is therefore developing approaches for multi-scale simulation of metasurface enabled products from nano-scale to meter-scale. The FABulous approach is to use rapid simulation to co-optimize the metasurfaces with the optical elements of the target products. Ensuring that the final products take maximum benefit from the integrated metasurface.

In the next phase of the project these tools will be deployed in the design of functional integrated metasurfaces for the FABulous use cases in the automotive and energy sectors.

Evaluating the life cycle impact of Fabulous products

FABulous aims to deliver an innovative high-efficiency manufacturing solution that will enable Europe's lead in industrial decarbonisation through the demonstration of sustainable manufacturing with reduced energy and resource consumption and increased productivity in three complementary use cases:

Manufacturing high efficiency solar cells for high altitude platform, enabling the design of smaller solar cells and increasing their efficiency from 20% to above 40%

Reducing the size and weight of automotive camera lenses, eliminating the need for optomechanical and chemical parts

Manufacturing high efficiency light pipes used in automotive lighting systems, increasing their efficiency from 10% to 50%.

Monitoring and evaluation of the capacity of the FABulous manufacturing approach to optimize the properties and performance of optical products whilst reducing their environmental footprint is therefore a central aspect of the FABulous project. To support this activity our sustainability and circularity partner IRES has been working to complete a benchmarking analysis of standard industrial practices for manufacturing equivalent products to the FABulous use cases and evaluate the environmental footprint of existing processes. The resulting data will be used in the next phase of the project to inform the development of the FABulous processes and evaluate the scale of reductions in environmental footprint that can be achieved with the FABulous solution.

Where can you connect with FABulous?

Date	Location	Details
June 2024	25th International Conference on Laser Precision Microfabrication, San Sebastian, Spain.	AIMEN Centro Tecnológico will be chairing a session on EU Projects, including FABulous
September 2024	18th International Congress on Artificial Materials for Novel Wave Phenomena – Metamaterials 2024	FORTH will be presenting their work on the design of optical metasurfaces.
September 2024	COLA 2024 - 17th International Conference on Laser Ablation	AIMEN will present a paper on Parallel 3D microfabrication using a SLM display

Remember you can also follow the FABulous social media channels for more information about the project and where you can interact with the team over the next few months.