A new method to print mirrors of variable size with a reflectivity of more than 99%

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Colored mirror layer printed onto a foil. Inkjet printing allows for structurization, such that large-area logos can be printed as well. Credit: Qihao Jin, KIT

Dielectric mirrors, also referred to as Bragg mirrors, reflect light nearly completely. Hence, they are suited for various applications, such as camera systems and sensor systems for microscopy and medical technologies. So far, such mirrors have been produced by complex

processes in expensive vacuum devices.

Researchers from Karlsruhe Institute of Technology (KIT) now are the first to print high quality Bragg mirrors with inkjet printers. This may pave the way towards the digital manufacture of customized mirrors. The research results are published in *Advanced Materials*.

Bragg mirrors are produced by applying several thin layers of materials onto a carrier. The resulting optical mirror specifically reflects the light of a certain wavelength. Reflectivity of a Bragg mirror depends on the materials, the number of layers applied, and their thicknesses. KIT researchers were the first to print them on different carriers. This largely facilitates production.

Inks made of nanoparticles

"It was a big challenge to develop suitable inks and to establish a reliable process for the production of several thin layers," says Professor Uli Lemmer from KIT's Light Technology Institute (LTI), who heads the project that is part of the "3D Matter Made to Order" cluster of excellence.

The constituents of the inks must have suitable optical properties and be soluble. Moreover, every layer should be as homogeneous as possible in order to obtain a consistent stack of layers. Pressure must be controlled precisely and results must be reproducible to guarantee excellent optical properties and a high reflectivity of the Bragg mirrors.

The research team decided to use nanoparticles. "Thanks to the rapid development of nanochemistry, nanoparticles are getting cheaper and more diverse," Lemmer says. His team used a mix of two different materials, titanium oxide and polymethyl methacrylate, as optical components of the inks. Using the inks, researchers succeeded in

producing extremely precise optical properties and thicknesses of the layers. "We reached a very high reflectivity of 99 % with ten double layers only," Lemmer says.

Printing on large and small areas

The method developed by the researchers from LTI may be used on very small areas down to ranges of a few micrometers, enabling production of optical components for microsystems technologies or camera systems. On the other hand, large areas of some square meters can be printed for solar modules, facades, and advertising displays.

Such mirrors have even been printed on flexible plastic foils. "The completely digital process enables fabrication of mirror layers that are precisely adjusted to the application. This is a great advantage compared to conventional fabrication methods," Lemmer says.

More information: Qiaoshuang Zhang et al, Fabrication of Bragg Mirrors by Multilayer Inkjet Printing, *Advanced Materials* (2022). DOI: 10.1002/adma.202201348

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