Plasmonic speed boost

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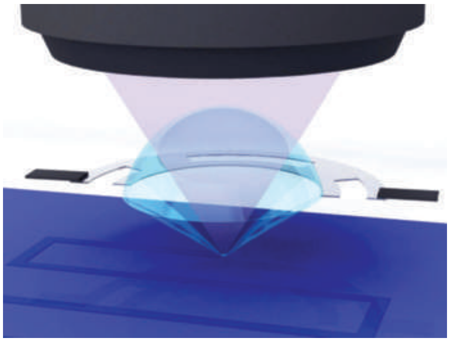

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Plasmonic lithography is a maskless technique that directly transfers patterns using scanning probes to achieve a spatial resolution beyond the diffraction limit of imaging optics. The approach uses surface plasmon–polaritions to enhance the transmission of light through a nanoscale aperture, generating a bright spot of light that is much smaller than the diffraction limit.

Plasmonic lithography has now been used by researchers in Korea to achieve a patterning resolution of 50 nm and a patterning speed of $10\ \mathrm{mm\ s^{-1}}$ — hundreds of times faster than that of conventional near-field recording.

“Although plasmonic lithography is a promising candidate for next-generation lithography, its main drawback is its low throughput,” admits Jae Hahn from Yonsei University in Seoul. “We believe high throughput can be achieved by using a parallel process with an array of optical probes.” This is difficult to implement, however, because the gap between each probe and the substrate must be accurately maintained to within a few tens of nanometres.

To study the feasibility of plasmonic lithography with a parallel probe array, Hahn’s team fabricated an optical contact probe with a lubricant layer between the probe’s aperture and the photoresist. The lubricant layer is a self-assembled monolayer that reduces friction and thus enables a high scanning speed to be achieved without any surface damage of the photoresist or probe. “This allows us to maintain the gap distance without an external control device during high-speed recording with the contact probe,” says Hahn. “We believe that our results represent remarkable progress towards the practical realization of plasmonic nanoscale lithography with an array of contact optical probes for high throughput.” The group is currently working with an instrument manufacturer to develop a prototype high-speed patterning system.

Aspheric answer

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The optical quality of holographic lithography can be significantly improved by using asphercial lenses, according to researchers at the European Commission’s Joint Research Centre (JRC) in Ispra, Italy.

Peter Macko and Maurice Whelan from the JRC’s Systems Toxicology Unit are using holographic lithography to produce diffractive optical elements for use in biochips. They found that longitudinal spherical aberration (LSA) in their optical set-up contributes to undesired distortion of the optical wavefront used for writing optical elements. The high LSA was due to the use of a spherical condenser lens and a half-ball lens in their apparatus. “We managed to reduce the LSA to almost zero by carefully selecting an aspherical lens and reducing the radius of the half-ball lens,” explains Macko. “We then used this aberration-free lithography set-up to make holographic diffractive optical elements that are integrated into biochips.”

The resultant optical elements enhance the collection of fluorescence by almost an order of magnitude when compared with other biochip designs.

“Our research has the potential to change the way the biosensors are designed by the industry; that is, to increase their efficiency and lower their detection limit,” says Macko. “Lower detection limits could certainly have a significant impact on clinical practice by making it possible to diagnose lethal diseases much earlier, through better detection of biomarkers in blood or urine.”

Making microneedles

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Microneedles with ultrahigh aspect ratios have been fabricated by researchers in Korea using a technique called drawing lithography, in which structures are drawn out of a thermoset polymer in liquid form and then cured. This form is then electroplated to fabricate hollow ultrahigh-aspect-ratio needles for minimally invasive and painless drug delivery. The needles are 2 mm long and have diameters in the micrometre range.

This new technique overcomes the height limitation of current subtractive-based lithography techniques. The microneedle height was controlled by altering the drawing rate and the time of lithography. The researchers believe that this drawing lithography technique is not limited to microneedle fabrication and can be used to create various 3D microstructural components of implantable medical devices and micro-electromechanical systems.

Self-assembly of nanocubes

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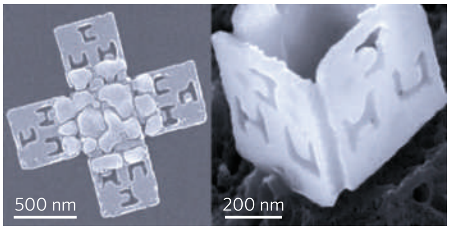

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Tiny self-assembling 3D cubes with intricate patterns etched in their sides have been fabricated by researchers in the US. The resulting structures could potentially be used as nanoscale encapsulants for biomedical purposes such as targeted therapeutics, as well as in other applications.

Lithographic nanoscale patterning techniques have traditionally been limited to creating 2D structures. Inspired by the biological self-assembly of nanoparticles in nature, Jeong-Hyun Cho and David Gracias of Johns Hopkins University developed a self-assembly method to create stable 3D polyhedral nanostructures in the lab.

The researchers use electron-beam lithography to produce flat nanoscale panels with intricate surface patterns, following which 2D nets of the desired 3D shapes are then created by linking the panels together with tin hinges, before arranging them on silicon wafer substrates. The wafers are then subjected to plasma etching with oxygen and carbon tetrafluoride gases to encourage the liquefaction of the tin hinges. Within a couple of minutes, the 2D net folds and fuses together in a precise fashion to produce the desired 3D nanostructure.

In their experiments, Cho and Gracias created 500-nm-long patterned cubes of nickel panels, and 100-nm-long cubes of multilayered gold and nickel panels. These nanostructures were stable enough to withstand temperatures of 500 °C at 1 atm with no visible change in shape.

The researchers suggest that it is possible to construct more complicated nanopolyhedra using their self-assembly method, as the angular orientation between panels can be controlled by altering the flow rate of oxygen gas during etching.