More precise method of nanopatterning

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“A nanoimprint method has already been achieved in nanopatterning with a high resolution using negative type photoresist,” Kosei Ueno tells PhysOrg.com. Ueno is a scientist at Hokkaido University in Sapporo, Japan, and associated with PRESTO. “However, some problems remain with the negative type photoresist.”

Ueno is part of a group, including Satoaki Takabatake, Ko Onishi, Hiroko Itoh, Yoshiaki Nishijima, and Hiroaki Misawa, working on lithography using positive type photoresist. “The positive type photoresist is ideal,” Ueno says. “We show nanopatterning with single nanometer resolution on positive type photoresist film for the first time.” The results of these efforts can be seen in *Applied Physics Letters*: “Homogeneous nano-patterning using plasmon-assisted photolithography.”

Up until now, one of the major problems with near-field lithography has been that nanopatterns on a photoresist film have been unable to reflect the patterns on a photomask with the desired nanoscale accuracy. Because of the near-field intensity profile, the nanopatterns fabricated using lithography can be shallow – and dependent on exposure dose. The technique demonstrated by Ueno and his colleagues can accurately fabricate deep nanopatterns, enhancing the use of near-field lithography.

“My current scientific interests are the fabrication and optical characterization of gold nanostructures defined with sub-nanometer precision,” Ueno explains. Indeed, this nano-patterning technique makes use of gold as part of the plasmon-assisted system. Nanostructured

photomasks were coated with gold film, created with the technique known as electron beam lithography.

“Using this method, metallic nanopatterns as well as semiconductor nanopatterns can be formed through the etching process,” Ueno says. In addition to being able to fabricate different nanopatterns reflected onto a photomask, the group was able to create precise nanopatterns suitable for a lift-off process, due to the use of positive photoresist film. The patterns created using negative photoresist are not usually suitable for lift-off.

Ueno and his colleagues think that this new lithography technique can be used to replace the current nanoimprint technology that makes use of negative photoresist. Among the possible future applications of this technique might even be in telecommunications. “We could apply the nanostructures created to the waveguide for telecom.” Indeed, the ability to lift-off with this lithography technique could probably provide waveguide structures for a number of applications in the future.

Right now, this fabrication process requires direct contact with the positive photoresit film that is spin-coated onto a substrate of glass. The next step, says Ueno, is to develop a system that does not require direct contact. “The development of the 10 nanomater-node photolithography system without contact exposure is planned according to utilizing the directional scattering components of light coupled with the radiation mode of plasmon resonance as an exposure source,” he explains.

If this technique gains widespread acceptance, there is a good possibility that it could be quite useful going forward. The shallowness and lack of complete precision at the nanoscale using negative photoresist means that this alternative might be attractive. The ability to create deeper patterns, and to perform the lift-off process, using positive photoresist is a step forward in nanopatterning.

More information: "Homogeneous nano-patterning using plasmon-assisted photolithography," *Appl. Phys. Lett.* 99, 011107 (2011); doi:10.1063/1.3606505