Periodic structures in organic light-emitters can efficiently enhance, replenish surface plasmon waves

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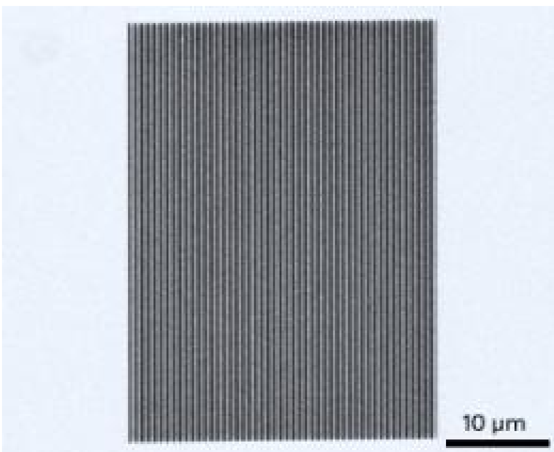

A scanning electron microscope image of an organic grating used to excite surface plasmons.

The irradiation of a metal surface with light or electrons can result in the formation of coherent electronic oscillations called surface plasmons, an effect ideal for applications such as optical communications on optoelectronic chips. Unfortunately, however, surface plasmons quickly lose their energy during transit, limiting their on-chip propagation distance. Jing Hua Teng at the A*STAR Institute of Materials Research and Engineering and co-workers from Nankai University and Nanyang Technological University under the Singapore-China Joint Research Program have now developed nanoscale structures that are able to replenish as well as guide surface plasmons on chips. “These structures can be used as plasmonic sources for lab-on-a-chip applications,” says Teng.

At the resonance frequency, surface plasmons can generate intense light fields close to the surface, especially in metallic nanostructures. For this reason, surface plasmons have been widely studied for a variety of sensing and light-focusing applications. However, the electrical resistance of metals inevitably causes losses in the movements of the electronic currents involved in surface plasmons. It is therefore important to develop schemes that are able to regenerate surface plasmons as they travel along the surface of a chip.

One possibility is the use of organic light-emitting molecules such as rhodamine B. The researchers embedded molecules of rhodamine B in a polymer matrix that was then poured onto the surface of a silver film. To couple the light emission from rhodamine B to the surface plasmons, the polymer layer was structured into a periodic grating (pictured) matched to the resonance frequency of the plasmons. Adjusting the shape and periodicity of the grating allows the light emitted from the surface plasmons to be tailored.

Similar gratings are also used as mirrors in conventional on-chip semiconductor lasers. This structural similarity raises the possibility of combining the plasmonic effects demonstrated here with existing laser designs—an approach that could well lead to the realization of a plasmonic laser.

The advantage of a plasmonic laser over a semiconductor laser is that it can be made much smaller, which is important for the miniaturization of photonic circuits and on-chip sensing applications. “However, such lasers are difficult to fabricate,” says Teng. “A number of challenges remain, including how to sufficiently confine the surface plasmons between the mirrors in this kind of configuration and how to reduce the metal damping losses."

Whether for applications in sensing or the on-chip manipulation of light, the potential of these gratings for replenishing plasmons represents an important step toward making plasmonics the key technology for photonic applications in nanoscience.

More information: Zhang, D. G., et al. Surface plasmon-coupled emission on metallic film coated with dye-doped polymer nanogratings. *Applied Physics Letters* 97, 231117 (2010). dx.doi.org/10.1063/1.3525576

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