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Plasmonic ceramic materials key to advances in nanophotonics for extreme operational conditions

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Progress in developing nanophotonic devices capable of withstanding high temperatures and harsh conditions for applications including data storage, sensing, health care and energy will depend on the research community and industry adopting new "plasmonic ceramic" materials, according to a commentary this week in the journal *Science*.

In one promising nanophotonic approach – plasmonics - clouds of electrons called surface plasmons are used to manipulate and control light on the nanometer scale. Plasmonic devices under development often rely on the use of metals such as gold and silver, which are not practical for most industrial applications because they are unable to withstand extreme heating and other harsh conditions. They also are not compatible with the complementary metal–oxide–semiconductor (CMOS) manufacturing process used to construct integrated circuits.

Now researchers are proposing the use of plasmonic ceramics such as titanium nitride and zirconium nitride instead of gold and silver.

"We have recently shown that plasmonic ceramics do offer properties similar to gold but have advantages that these noble metals don't have," said Alexandra Boltasseva, an associate professor of electrical and computer engineering at Purdue University.

She co-authored a Perspectives article this week in *Science* with Vladimir

M. Shalaev, scientific director of nanophotonics at Purdue's Birck Nanotechnology Center and a distinguished professor of electrical and computer engineering.

Plasmonic ceramic materials are promising for various potential advances, including far denser data recording and storage than now possible; sensors capable of withstanding high-temperatures for the oil and gas industries; new types of light-harvesting and waste energy recovering systems; electronic circuits that harness light to process information; and cancer treatment.

"It may be only a few years before we have some devices and new functionalities made possible by plasmonics," Boltasseva said.

Shalaev and Boltasseva formed Nano-Meta Technologies Inc. in the Purdue Research Park, and are working to develop new technology for data recording in computer hard drives based on heat-assisted magnetic recording, or HAMR; solar thermophotovoltaics, in which an ultrathin layer of plasmonic "metamaterials" could improve solar cell efficiency; and a new clinical therapeutic approach using nanoparticles for cancer treatment.

HAMR could make it possible to record data on an unprecedented small scale using "nanoantennas" and increase the amount of data that can be stored on a standard magnetic disk by 10 to 100 times, Shalaev said.

In cancer therapy, nanoparticles are injected into the bloodstream and aggregate around tumors. When exposed to a light source, they heat up, killing cancer cells. However, gold particles offer a challenge because they must be fashioned into specific geometric shapes such as "nanoshells," or they will not work.

"But with titanium nitride we can use simple and small particles like nanospheres, and they will function just as well as the complex geometries required for gold," Boltasseva said.

Other potential applications include tiny photodetectors and light interconnects and modulators small enough to fit on electronic chips.

More information: All that glitters need not be gold, *Science* 20 March 2015: Vol. 347 no. 6228 pp. 1308-1310 DOI: 10.1126/science.aaa8282

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