Sculptured materials allow multiple channel plasmonic sensors

November 10 2009

(PhysOrg.com) -- Sensors, communications devices and imaging equipment that use a prism and a special form of light -- a surface plasmon-polariton -- may incorporate multiple channels or redundant applications if manufacturers use sculptured thin films.

"Everyone uses surface plasmon resonance sensors. They are a multi billion-dollar industry worldwide," said Akhlesh Lakhtakia, the Charles Godfrey Binder (Endowed) professor of engineering science and mechanics, Penn State. "This type of sensor provides a fairly quick way to see what you have. It can tell you the concentration of chemicals, but in order to test for more than one chemical today, manufacturers have to use more than one sensor."

Surface plasmon resonance devices currently have a wide range of applications. They are commercially used as sensors for humidity, temperature, chemical concentrations and chemical composition. SPR devices can be used in a form of surface microscopy, as wave guides and tunable filters. Creating two or more channels in each device would multiply SPR utility in all areas of application.

Surface plasmon-polaritons are electromagnetic waves that flow along a sandwich of a metal and a dielectric. When light shines through a prism onto the sandwich, electrons form a cloud or plasma in the metal and the molecules of the dielectric get stretched or polarized. Under special conditions, a plasmon-polariton combination forms and moves as a single unit along the sandwich. The formation can be disturbed by the presence of an additional chemical in the dielectric. The disturbance provides the sensing principle. Useful as they are, each sensor can only detect one chemical for each prism and sandwich.

In a series of papers Lakhtakia and his colleagues report on their theoretical and experimental investigation into the possibility of propagating more than one surface plasmon-polariton wave of the same color on a substrate. They recently reported on their experimental work in the *Journal of Nanophotonics* and the journal *Electonic Letters*.

The theoretical work indicated that for one wavelength or color of light, it should be possible to generate not just one, but up to three possible plasmon-polaritons if the dielectric used is not a traditional material, but a periodically non-homogeneous sculptured nematic thin film.

"Just because the mathematics suggest three possible surface plasmon-polariton waves does not mean that they can actually all be created," said Lakhtakia. "We had to find someone who could produce the thin films that we needed to test the possibilities experimentally."

Yi-Jun Jen, professor and chair, and Chia-Feng Lin, graduate student, both of the department of electro-optical engineering, National Taipei University of Technology, fabricated the sculptured nematic thin films that were then used in a standard Kretschmann surface plasma resonance sensor configuration. The researchers found that they produced three surface plasmon-polariton waves of light with the same wavelength or color, but with three different speeds. Two of these were polarized in one direction -- p polarized -- and the third was polarized in the other direction - s polarized.

"This would allow us to test more than two things or to test for the same thing twice in order to reduce sensing errors," said Lakhtakia.

The key to this finding is that sculptured thin films are not the same structure along their thickness. Instead, the pattern of sculpturing does periodically repeat. This periodicity allows the production of two or more surface waves of the same wavelength.

Lakhtakia, working with Devender, an international undergraduate research intern and Drew Patrick Pulsifer, graduated student in engineering science and mechanics, next tried a chiral sculptured thin film. Chiral thin films are similar to periodic sculptured nematic thin films but are like a multitude of parallel corkscrews. Using these thin films the researchers generated two surface plasmon-polaritons waves, but with different speeds, both with p-polarized light.

"If this approach can be optimized and commercialized, there are exciting prospects in store for plasmonic-based sensing, imaging and communications," said Lakhtakia.

Source: Pennsylvania State University (news : web)

Citation: Sculptured materials allow multiple channel plasmonic sensors (2009, November 10) retrieved 2 May 2024 from
https://phys.org/news/2009-11-sculptured-materials-multiple-channel-plasmonic.html