Scientists develop high-precision sensor based on laser-textured gold film

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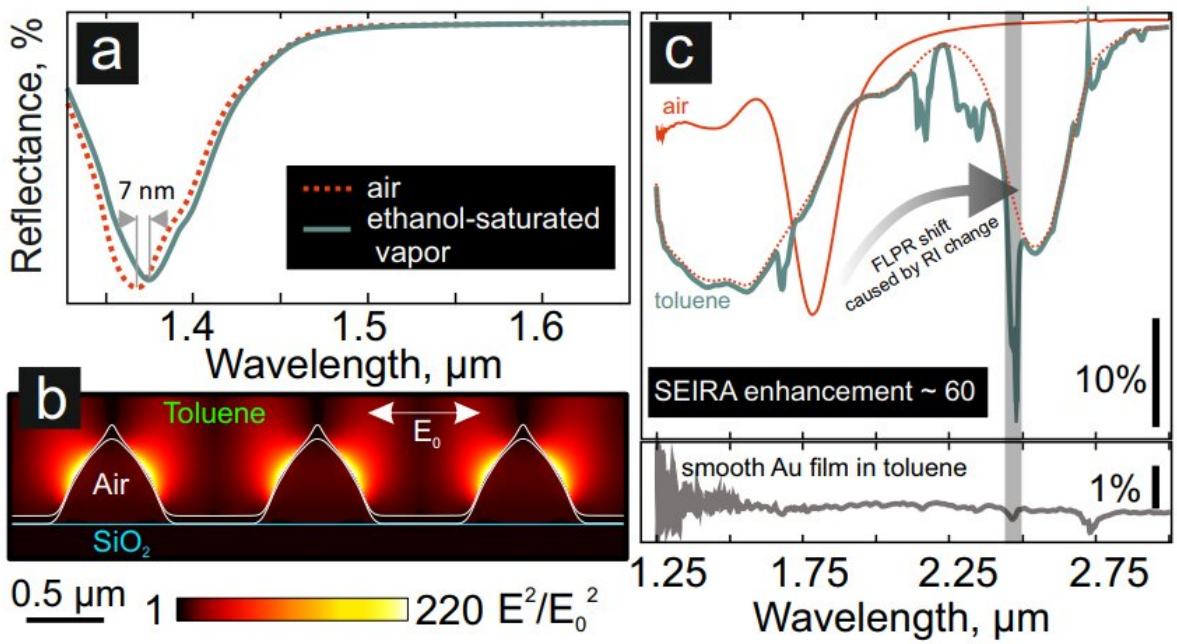

Various applications of the First-order lattice plasmonic resonance (FLPR)a) Spectral response of the nanovoid array SP sensor caused by injection of saturated ethanol vapour. (b) Squared normalised EM-field amplitude E2/E2 0 calculated near the surface of the nanovoid array immersed in toluene, upon its excitation from the top by a linearly-polarised source at a 2.5-μm wavelength. (c) FTIR reflection spectra of the nanovoid array in air and under the toluene liquid layer. The dashed curve provides the contribution of the nanovoid array to the reflection spectrum, if taken without the absorption of toluene. The bottom panel shows the FTIR reflection from the smooth Au film surface covered by toluene obtained under the same conditions. Credit: FEFU

Scientists at Far Eastern Federal University (FEFU) with colleagues from Russia, Japan, and Australia have developed a multi-purpose sensor based on a specially designed gold film, the surface of which contains millions of parabolic nanoantennas produced by femtosecond laser printing. The sensor identifies molecules at trace concentrations, detecting them in liquid and gas environments. It can be easily adjusted to provide different modalities, including biological studies, medical and security tasks. The related research is published in *Nanomaterials*.

The sensor reacts to the tiniest changes of the surroundings in the close proximity to its surface, e.g. gas or organic molecules, changes in the local refractive index of a liquid, etc. and can be applied for bioanalysis, environmental monitoring, food quality analysis, and various security systems.

"Despite the significant progress that science has made in the field of high-precision physicochemical sensors over the past several decades, flexible inxpensive technologies for manufacturing cheap multi-purpose sensors combining different measurement modalities within a single device are still required. Existing lithographic technologies for such sensors fabrication are time and money consuming and therefore are not suitable for mass production. We proposed efficient and cheap laser printing technology to solve the mentioned issue. Using it we can easily produce sensor elements with the desired surface morphology and resonant properties, optimized to merge different sensing modalities and to have sufficient mechanical strength to operate in liquid environments," said Aleksandr Kuchmizhak, research fellow at the FEFU STI for Virtual and Augmented Reality.

The sensor system based on nanotextured gold film was fabricated by direct femtosecond-laser printing. The exposure of such an ultrathin gold film to single femtosecond pulses resulted in formation of millions of hollow parabolic nanostructures (nanovoids), the so-called nanoantennas.

An ordered array of these nanostructures has pronounced resonant optical properties. They effectively convert incident radiation of the visible and IR spectral ranges into special surface waves, so-called surface plasmons, which provide the sensor with its remarkable sensitivity to changes in the surroundings.

Scientists from FEFU, FEB RAS and MEPhI, as well as from Nagoya Institute of Technology (Japan), Tokai University (Japan) and Swinburne University of Technology (Australia) took part in the work.

Previously, scientists from FEFU and Swinburne University of Technology teamed up with Indian and Japanese colleagues, had developed an optical element based on an array of cross-shaped silicon nanoantennas. Being arranged in an appropriate way, these nanoantennas formed a spiral waveplate for middle-IR and THz spectral ranges allowing for the conversion of an ordinary Gaussian beam to a singular vortex beam. The optical element aimed to conduct advanced laboratory studies of the proteins' structure in IR spectral range, as well as to study new chiral molecular compounds.

More information: Dmitrii V. Pavlov et al, Multi-Purpose Nanovoid Array Plasmonic Sensor Produced by Direct Laser Patterning, *Nanomaterials* (2019). DOI: 10.20944/preprints201908.0307.v1

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