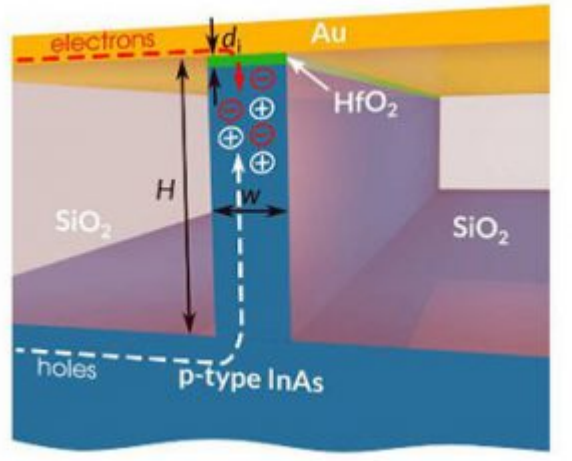
A Step Toward Practical Plasmonic Chips?

Optoelectronics researchers in Russia have proposed a new design for a fast plasmonic chip, with the potential to dramatically cut the large energy losses that have typically blocked practical use of such devices.

Plasmonic components on integrated circuits—in which energy from light is concentrated into surface plasmon polaritons (SPPs), sub-wavelength electromagnetic oscillations that can propagate along a metal-dielectric interface—have significant promise for enabling large-scale integration in nanoscale optoelectronic chips and devices. That's because SPPs offer the potential for breaking the diffraction limit imposed by the micrometer-scale wavelength of light in conventional waveguides, and allowing for the nanometer-scale integration common in electronic chips.



But there's a catch: SPP propagation requires a metal interface, and that means that the electric field attenuates quickly through absorption in the metal—dropping off, according to Fedyanin, a billion times at distances of around a millimeter. And, while it's possible to compensate for these losses by pumping additional energy into the system, the optical pumping schemes demonstrated thus far to do so have

required a large, impractical energy input.

The added insulating layer helps to suppress leakage current and ohmic losses in the metal layer. And, when a forward bias voltage is applied, it allows a sufficient concentration of electrons near the semiconductor-insulator-metal interface to create a population inversion in the semiconductor and provide optical gain for the plasmonic mode propagating in the waveguide—amplification that compensates for SPP propagation losses.

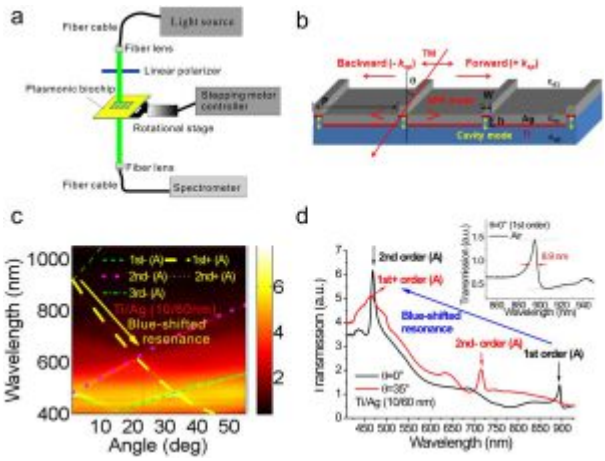
In numerical models of the geometry, using a hypothetical system with gold as the metal layer, hafnium dioxide as the insulator, and the *p*-type semiconductor indium arsenic, the team calculated that the system could fully compensate for SPP propagation losses "at a current density of only 2.6 kA/cm^2." Replacing gold with copper, which significantly increases the minority-carrier injection efficiency, dropped the required current density to 0.8 kA/cm^2. "Such an exceptionally low value," the study concludes, "demonstrates the potential of electrically pumped active plasmonic waveguides and plasmonic nanolasers for future high-density photonic integrated circuits."

For more information: doi: 10.1364/OE.23.019358

Enhancing Surface Sensing Sensitivity of Metallic

Nanostructures using Blue-Shifted Surface Plasmon Mode and Fano Resonance

Improving surface sensitivities of nanostructure-based plasmonic sensors is an important issue to be addressed. Among the SPR measurements, the wavelength interrogation is commonly utilized. We proposed using blue-shifted surface plasmon mode and Fano resonance, caused by the coupling of a cavity mode (angle-independent) and the surface plasmon mode (angle-dependent) in a long-periodicity silver nanoslit array, to increase surface (wavelength) sensitivities of metallic nanostructures. It results in an improvement by at least a factor of 4 in the spectral shift as compared to sensors operated under normal incidence. The improved surface sensitivity was attributed to a high refractive index sensitivity and the decrease of plasmonic evanescent field caused by two effects, the Fano coupling and the blue-shifted resonance. These concepts can enhance the sensing capability and be applicable to various metallic nanostructures with periodicities.



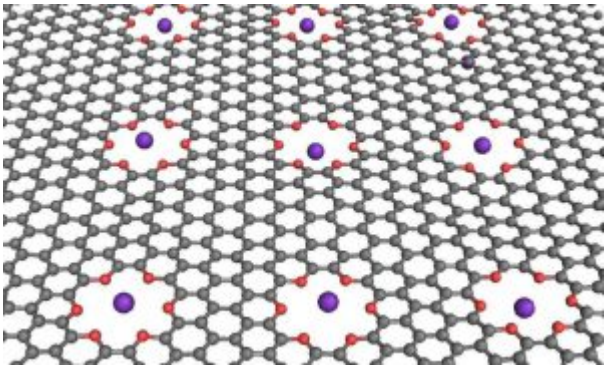
Optical setup and optical properties of 900-nm-period Ti/Ag capped nanoslits with normal and oblique-angle incidence. (**a**) Optical setup for measuring angular transmission spectra. (**b**)

Schematic configuration depicts the geometrical parameters of capped nanoslits with a 10-nm-thick titanium and 60-nm-thick silver film and the direction of the TM-polarized incident light. (**c**) Measured angular transmission diagram in air for 900-nm-period capped nanoslit arrays with a Ti/Ag film. The color dashed lines show the theoretical resonance wavelengths for the SPR mode. (**d**) Measured transmission spectra in air at 0° and 35° for 900-nm-period capped nanoslit arrays with a Ti/Ag film.

For more information: https://www.nature.com/articles/s41598-018-28122-5

Researchers simulate simple logic for nanofluidic computing

Invigorating the idea of computers based on fluids instead of silicon, researchers at the National Institute of Standards and Technology (NIST) have shown how computational logic operations could be performed in a liquid medium by simulating the trapping of ions (charged atoms) in graphene (a sheet of carbon atoms) floating in saline solution. The scheme might also be used in applications such as water filtration, energy storage or sensor technology.



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NIST’s ion-based transistor and logic operations are simpler in concept than earlier proposals. The new simulations show that a special film immersed in liquid can act like a solid silicon-based semiconductor.

The NIST molecular dynamics simulations focused on a graphene sheet 5.5 by 6.4 nanometers (nm) in size and with one or more small holes lined with oxygen atoms. These pores resemble crown others electrically neutral circular molecules known to trap metal ions.

In the NIST simulations, the graphene was suspended in water containing potassium chloride, a salt that splits into potassium and sodium ions. The crown ether pores were designed to trap potassium ion, which have a positive charge.

Applying voltages of less than 150 mV across the membrane turns “off” any penetration. Essentially, at low voltages, the membrane is blocked by the trapped ions, while the process of loose ions knocking out the trapped ions is likely suppressed by the electrical barrier. Membrane penetration is switched on

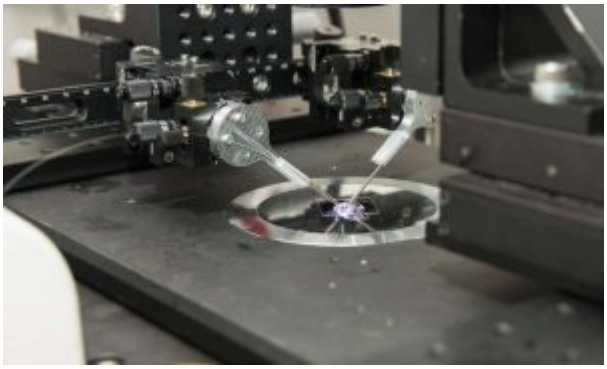
at voltages of 300 mV or more. As the voltage increases, the probability of losing trapped ions grows and knockout events become more common, encouraged by the weakening electrical barrier. In this way, the membrane acts like a semiconductor in transporting potassium ions.

More information: Alex Smolyanitsky et al. Aqueous Ion Trapping and Transport in Graphene-Embedded 18-Crown-6 Ether Pores, *ACS Nano* (2018). DOI: 10.1021/acsnano.8b01692

Researchers taking optical device out of the lab and into the clinic to detect cancer at its earliest stages

In a paper published in Nature Scientific Reports, a team of researchers at Worcester Polytechnic Institute (WPI) has demonstrated how a device that uses beams of light to grip and manipulate tiny objects, including individual cells, can be miniaturized, opening the door to creating portable devices small enough to be inserted into the bloodstream to trap individual cancer cells and diagnose cancer in its earliest stages.

The technique, known as optical tweezers, uses optical beams of laser light to create an attractive force field that can hold, or trap, small objects in place without physical contact. Traditional optical tweezers focus the light with a large and expensive lens, which makes the device bulky and susceptible to environmental fluctuations. These limitations make optical tweezers impossible to use outside the lab.



“Currently, to test for cancer, you must wait until there’s a visible tumor or a sufficient volume of cancerous cells in a blood sample,” he said. “By that time, the cancer may be advanced. But cancer starts with single cells. If doctors could separate those cells from among millions of blood cells, we could detect cancer much sooner—at a point where it’s not visible using other techniques. This could advance diagnoses by months or even years and make treatment much more successful.”

Read more at: https://phys.org/news/2017-12-optical-device-lab-clinic-cancer.html#jCp

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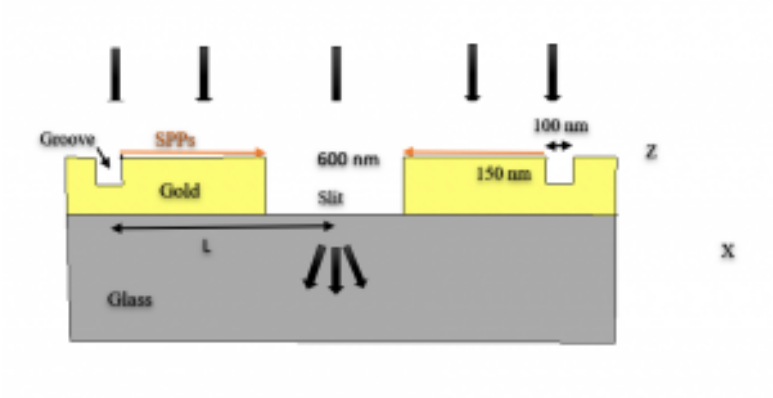
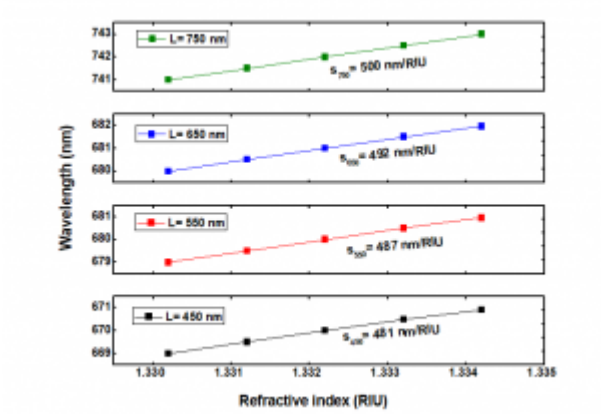
Our new paper in optics communication

Congratulations for the publication of paper” Highly Sensitive Biochemical sensor based on Nanostructured Plasmonic Interferometer” , by Khajemiri , S. M. Hamidi , Om. K. Suwal.

We propose a novel plasmonic interferometric sensor with a slit and surrounding rectangular grooves array on an optically

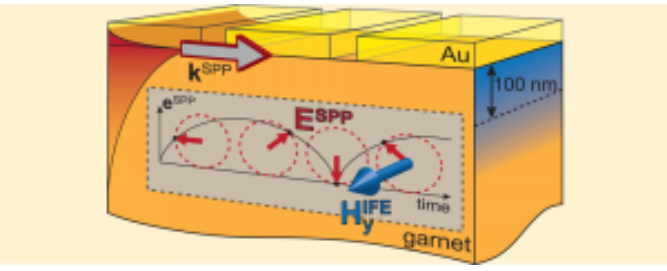
thick gold film for biochemical sensing. We did finite-difference time-domain (FDTD) simulation for design optimization and analytical calculation for characterization of sensitivity in the proposed sensor. Our interferometer is functional for visible to near infrared region with maximum sensitivity of 500 nm/RIU and figure of merit 1933 at 741 nm wavelength. The peak intensity and wavelength change in different refractive indices. In conclusion, the results obtained in the present study indicate the potential of the proposed plasmonic interferometer as a low cost, compact, and label-free high-throughput device.





Surface Plasmon-Mediated Nanoscale Localization of Laser-Driven sub-Terahertz Spin Dynamics in Magnetic Dielectrics

We report spatial localization of the effective magnetic field generated via the inverse Faraday effect employing surface plasmon polaritons (SPPs) at Au/garnet interface. Analyzing both numerically and analytically the electric field of the SPPs at this interface, we corroborate our study with a proof-of-concept experiment showing efficient SPPdriven excitation of coherent spin precession with 0.41 THz frequency. We argue that the subdiffractional confinement of the SPP electric field enables strong spatial localization of the SPP-mediated excitation of spin dynamics. We demonstrate two orders of magnitude enhancement of the excitation efficiency at the surface plasmon resonance within a 100 nm layer of a dielectric garnet. Our findings broaden the horizons of ultrafast spin-plasmonics and open pathways toward nonthermal optomagnetic recording on the nanoscale.



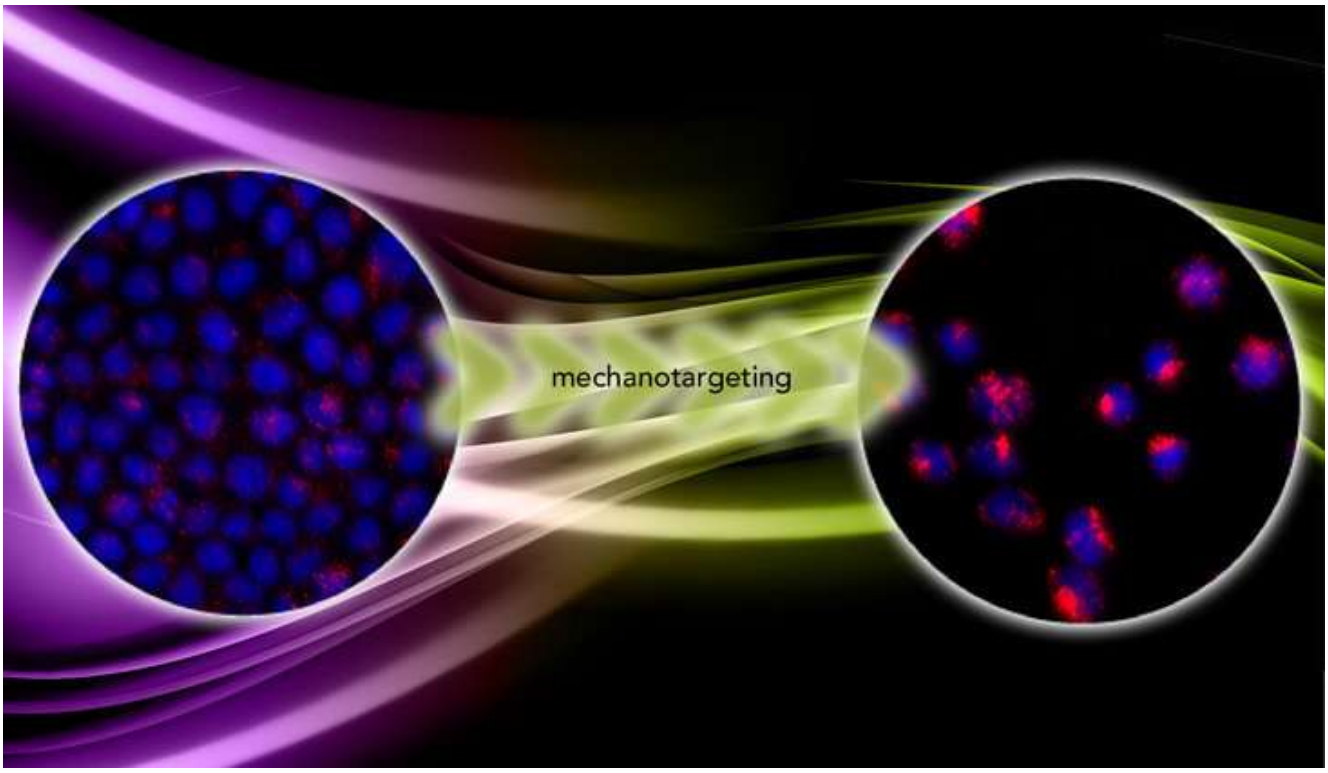
KEYWORDS: Ultrafast spin dynamics, surface plasmon−polariton, inverse Faraday effect, rare-earth iron garnet, nonlinear optics, Magnetoplasmonics

Effective static magnetic field induced by a propagating SPP at the Au/magnetic garnet interface.

https://pubs-acs-org.ezp3.semantak.com/doi/10.1021/acs.nanolett.8b00416

Targeting strategy may open door to better cancer drug delivery

Bioengineers may be able to use the unique mechanical properties of diseased cells, such as metastatic cancer cells, to help improve delivery of drug treatments to the targeted cells, according to a team of researchers at Penn State.



Many labs around the world are developing nanoparticle-based, drug delivery systems to selectively target tumors. They rely on a key-and-lock system in which protein keys on the surface of the nanoparticle click into the locks of a highly expressed protein on the surface of the cancer cell.

The adhesive force of the lock and key is what drives the nanoparticle into the cell, said Sulin Zhang, professor of engineering science and mechanics.

The resistive force is the mechanical energy cost required for the membrane to wrap around the nanoparticle. Until now, bioengineers only considered the driving force and designed nanoparticles to optimize the chemical interactions, a targeting strategy called "chemotargeting." Zhang believes they should also take into account the mechanics of the cells to design nanoparticles to achieve enhanced targeting, which forms a new targeting strategy called "mechanotargeting."

"These two targeting strategies are complementary; you can combine chemotargeting and mechanotargeting to achieve the full potential of nanoparticle-based diagnostic and therapeutic agents," Zhang said. "The fact is that targeting efficiency requires a delicate balance between driving and resistive forces. For instance, if there are too many keys on the nanoparticle surface, even though these keys only weakly interact with the nonmatching locks on normal cells, these weak, off-target interactions may still provide enough adhesion energy for the nanoparticles to penetrate the cell membrane and kill the healthy cells."

In "Mechanotargeting: Mechanics-dependent Cellular Uptake of Nanoparticles," On soft hydrogels the cells remained cohesive and benign and experienced a nearly constant stress that limited the uptake of the nanoparticles. But on stiff hydrogels the cells became metastatic and adopted a three-dimensional shape, offering more surface area for

nanoparticles to adhere, and became less stressed. Under this condition, the cells took up five times the number of nanoparticles as the benign cells.

“The nanoparticles are fluorescent, so we count the number of nanoparticles that get into the cell by the fluorescence intensity. We found that in the malignant cells the intensity is five times higher,” Zhang said. “That proves that mechanotargeting works.”

Explore further: Nanoparticle aggregates for destruction of cancer cells

More information: Qiong Wei et al, Mechanotargeting: Mechanics-Dependent Cellular Uptake of Nanoparticles, *Advanced Materials* (2018). DOI: 10.1002/adma.201707464

Journal reference: Advanced Materials.

Provided by: Pennsylvania State University .

Read more at: https://phys.org/news/2018-06-strategy-door-cancer-drug-delivery.html#jCp

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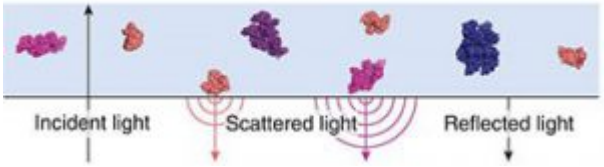
OPSI; Optics and Photonics Society Of Iran Newsletter

Vol 3-21 March-April 2018 of Optics and Photonics Society Of Iran Newsletter.

Weighing Biomolecules with Light

From imaging to mass measurement



In the authors' interferometric detection scheme, iSCAMS, the scattering signal scales with the polarizability, which is a function of the refractive index and proportional to the particle volume. That allows users to infer the mass of proteins from the scattering signal.

In existing, fluorescence-based techniques for looking at biomolecular structures and interactions, molecules must first be labeled and excited, and then emission collected from them. Other, static methods involve averaging over many molecules in a sample, and thus can't provide accurate spatiotemporal information or reflect the diversity in a sample. And state-of-the-art mass spectrometry works only in a vacuum, so it isn't suitable for studying many biological systems in their living state.

The team behind the new research, led by University of Oxford chemists Justin Benesch and Philipp Kukura, sought a different approach—one flexible enough to look at small samples in solution, but without labelling and with improved spatiotemporal accuracy and resolution. They found a potential answer by leveraging interferometry. The researchers had, in

fact, first used light scattering to image proteins back in 2014, and since then have improved the sensitivity of their technique to the point where they say it’s competitive with traditional fluorescence measurements.

The team also realized, though, that since the scattering signal scales with polarizability—which is a function of refractive index and is proportional to particle volume—its microscope should be sensitive to mass. More specifically, the researchers observed that there is very little variation (only around 1 percent) in the volumes of amino acids and the refractive indices of proteins. Since single amino acids can be considered as nano-objects, the team reasoned, the scattering signal should be proportional to the number of amino acids in a polypeptide, and thus to its mass.

From links to chains to amyloids

The group led by Benesch and Kukura, which also included other Oxford researchers and scientists from universities in Sweden, the United States, Germany and Switzerland, obtained high-quality images of single proteins diffusing from solution to bind with the interface between the microscope cover slip and solution. The signal-to-noise ratios were such that, by optimizing their data analysis, the scientists could precisely determine the scattering contrast for a single molecular binding event.

From there, the researchers obtained signatures for different oligomers—short macromolecule complexes consisting of a few simpler units—and their relative abundances. They repeated the experiments on eight different proteins to establish a linear relationship between mass and interferometric contrast, and confirmed the precision of the technique.

Once that was done, the researchers moved on to more complex systems. They were able to follow and model the evolution of various oligomeric species, and resolve changes in mass in

both space and time; that enabled them, for example, to examine surface-catalyzed nucleation events that may eventually lead to the formation of amyloids, the proteins implicated in some neurodegenerative diseases (such as Parkinson's). In other words, team co-leader Benesch suggested in a press release accompanying the work, the technique allows examination of questions such as whether molecules interact, how tightly, what the composition of a protein is, and how proteins grow or fall apart.

Broadly applicable

The relationship between volume, optical properties, and mass holds for molecules containing lipids and carbohydrates, as well as proteins, according to the team, so iSCAMS can be applied quite broadly. Indeed, the team finds that general applicability "tremendously exciting," team co-leader Kukura said in a press release. Essentially, the researchers point out, every physiological and pathological process involves biomolecular interactions in solution—and mass is a universal property that reveals a lot about the molecule being investigated. The technique, Kukura says, allows users to see those properties and processes playing out in real time—using a compact, "shoebox-size" instrument that's easy to operate.

The team is working on commercializing the technology and feels iSCAMS has the potential to "revolutionize how we study biomolecules and their interactions."

more information on: doi: 10.1126/science.aar5839

Our New Paper in Optical Materials

Congratulations for the publication of paper”Exciton-Plasmon Coupling in Two-dimensional plexitonic nano Grating”, in journal of optical materials by N. Asgari and S. M. Hamidi.