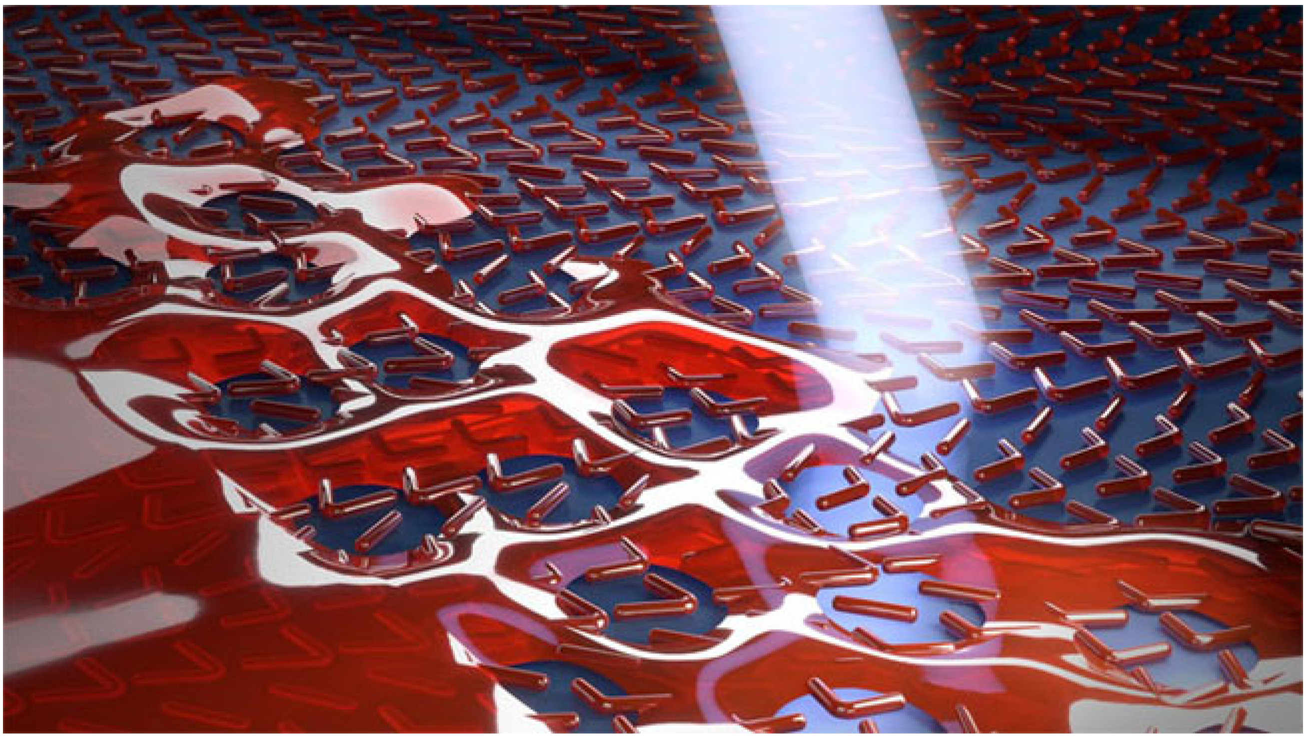
[A New Way to Fabricate High-Performance Optical Metasurfaces for Use in Photonic Circuits]

LAUSANNE, Switzerland, Feb. 13, 2019 — A way to produce glass metasurfaces that can be either rigid or flexible, developed by engineers from the EPFL Laboratory of Photonic Materials and Fiber Devices, could be used to fabricate all-dielectric optical metasurfaces quickly, at low temperatures, and with no need for a cleanroom. These metasurfaces could be used to build next-generation photonic circuits. Optical circuits, which are 10 to 100 times faster than electronic circuits and more energy-efficient, could transform the performance of many devices.



The new method employs dewetting, a natural process that occurs when a thin film of material is deposited on a substrate and then heated. The heat causes the film to retract and break apart into tiny nanoparticles.

The EPFL engineers used dewetting to create dielectric glass metasurfaces, rather than metallic metasurfaces. First, they created a substrate textured with the desired architecture. Then, they deposited the material — chalcogenide glass — in thin films just tens of nanometers (nm) thick. The substrate was heated for a couple of minutes until the glass became fluid and nanoparticles began to form in the sizes and positions dictated by the substrate’s texture.

The engineers demonstrated the ability to tailor the position, shape, and size of nano-objects with feature sizes below 100 nm and with interparticle distances down to 10 nm. They used their method to generate optical nanostructures over rigid and soft substrates that were several centimeters in size, with optical performance and resolution comparable to traditional lithography-based processes. The metasurfaces are highly sensitive to changes in ambient conditions, thus able to detect the presence of very low concentrations of bioparticles, the team said.

Metasurfaces could enable engineers to make flexible photonic circuits and ultrathin optics for a host of applications, ranging from flexible tablet computers to solar panels with enhanced light-absorption characteristics. They could also be used to create flexible sensors to be placed directly on a patient’s skin, for example, to measure things such as pulse and blood pressure or to detect specific chemical compounds.

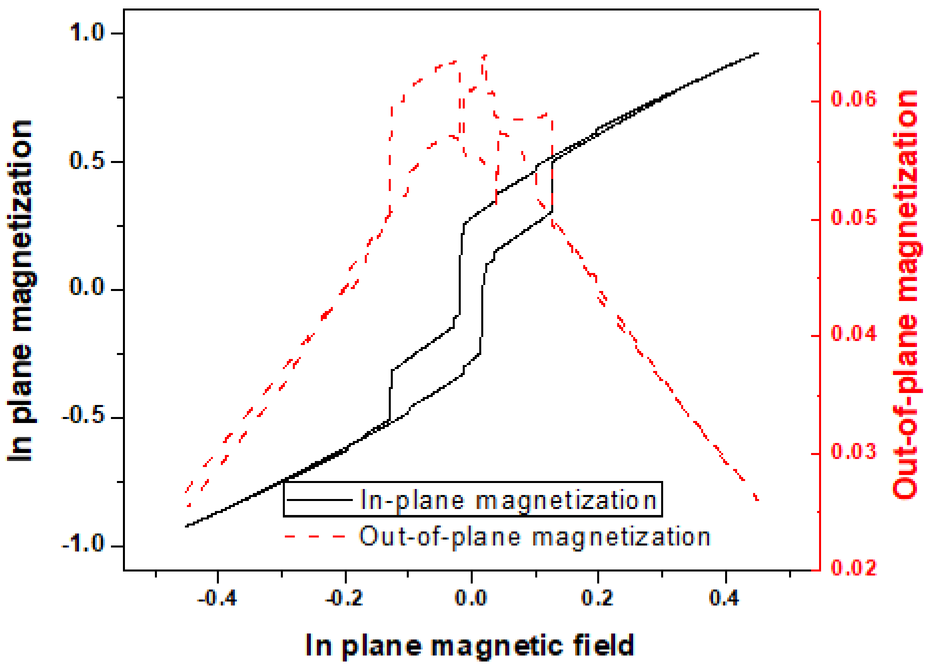
For more information:

https://doi.org/10.1038/s41565-019-0362-9

Our new paper in journal of magnetism and magnetic materials

Congratulations to our new paper " Experimental study and micro-magnetic modeling of magnetization dynamics in L10-FePt thin film" by M. Shafei, M. M. Tehranchi, H. Falizkaran Yazdi, S. M. Hamidi, R. Yusupov, S. Nikitin

Among different magnetic thin films, *L*1 FePt due to high magnetocrystalline anisotropy is attracting much attention for applications in new generation of magnetic recording media. In this work, switching time and switching mechanism of magnetization as essential properties of *L*1 FePt film was studied by magneto-optical Kerr effect (MOKE) and time-resolved magneto-optical Kerr effect (TR-MOKE). For this purpose, static in plane and out of plane magnetic hysteresis loop of a *L*1 FePt film on (100) MgO was measured and modeled using polar and longitudinal MOKE and mumax code respectively. Furthermore, the switching time of magnetization was studied using laser induced ultrafast demagnetization and relaxation of the sample by TR-MOKE, in which for the first time, the magnetic field was applied in the plane of the sample for this measurement.



[Surface Plasmon Resonance in a metallic nanoparticle embedded in a semiconductor matrix: exciton-plasmon coupling]

They consider the effect of electromagnetic coupling between localized surface plasmons in

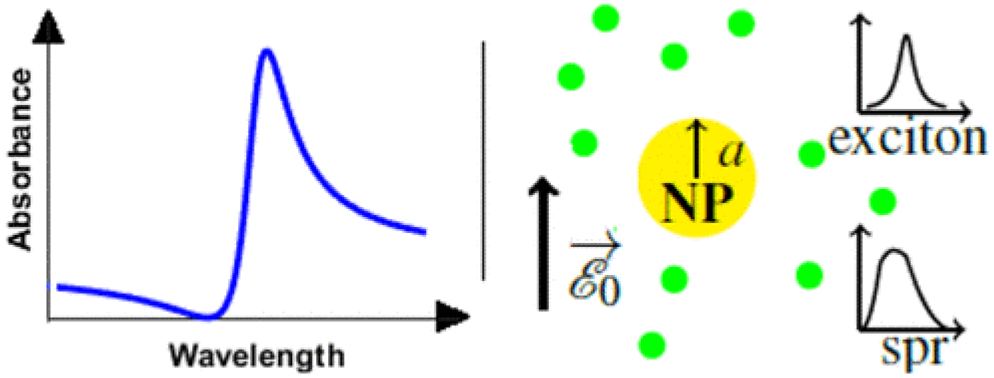
a metallic nanoparticle (NP) and excitons or weakly interacting electron-hole pairs in a semiconductor matrix where the NP is embedded.

An expression is derived for the NP polarizability renormalized by this coupling and two possible situations are analyzed, both compatible with the conditions for Fano-type resonances:

- a narrow-bound exciton transition overlapping with the NP surface plasmon resonance (SPR), and
- SPR overlapping with a parabolic absorption band due to electron-hole transitions in the semiconductor.

The absorption band line shape is strongly non-Lorentzian in both cases and similar to the typical Fano spectrum in the case (i).

However, it looks differently in the situation (ii) that takes place for gold NPs embedded in a CuO film and the use of the renormalized polarizability derived in this work permits to obtain a very good fit to the experimentally measured LSPR line shape.

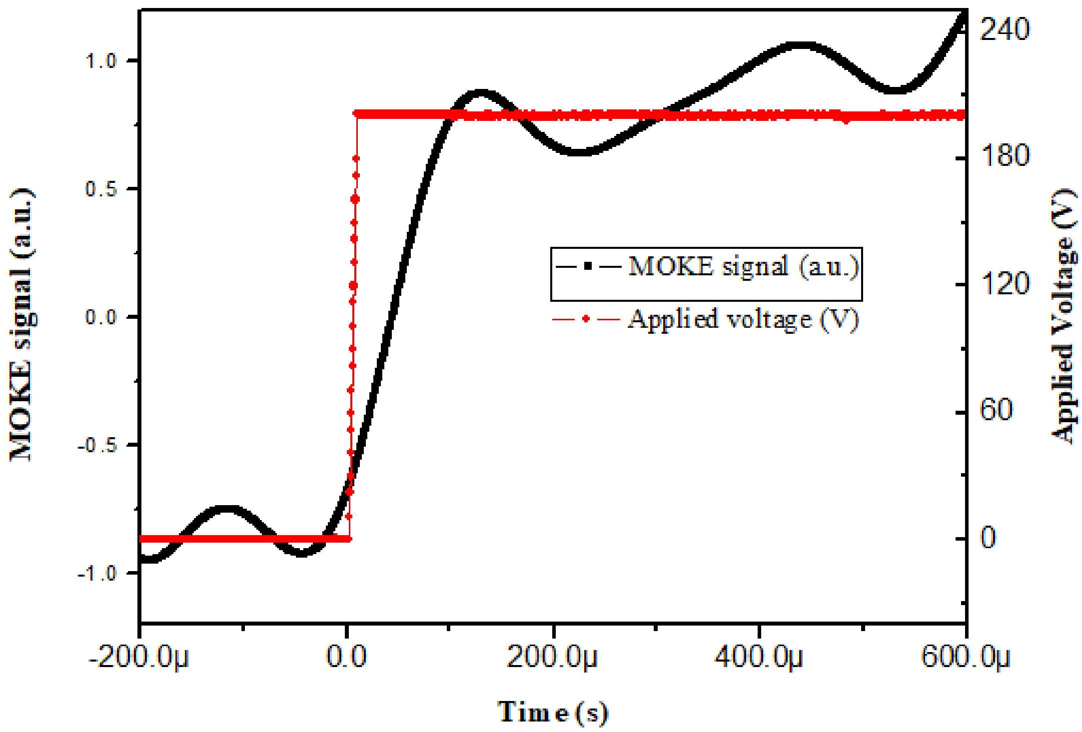


[Our new paper in journal of superconductivity and novel magnetism]

Congratulations to our new paper " Switching time Probing in electric field assisted magnetization of PbZrTiO3/Cobalt structure " by M. Shafei, M. M. Tehranchi, S. M. Hamidi

Electric field assisted full
magnetization switching in a multiferroic heterostructure composed of a $PbZrTiO_3$
(PZT) substrate and 100nm Cobalt (Co) layer was investigated. For this, by
measuring magnetic in plane anisotropy of the sample, using magneto-optical
Kerr effect (MOKE), it was shown that the sample has a uniaxial anisotropy. In
addition, the coercive field of the Co layer can be tuned by applying an electric
field to the PZT which can be used in electric field assisted magnetization

reversal in the Co layer. Direct measurement reveals that electric field assisted magnetization switching in layers take place in about 100 μs that is in compatibility with domain wall motion. Our measurement is a promising technique for probing of switching time in electric field assisted magnetization switching elements.



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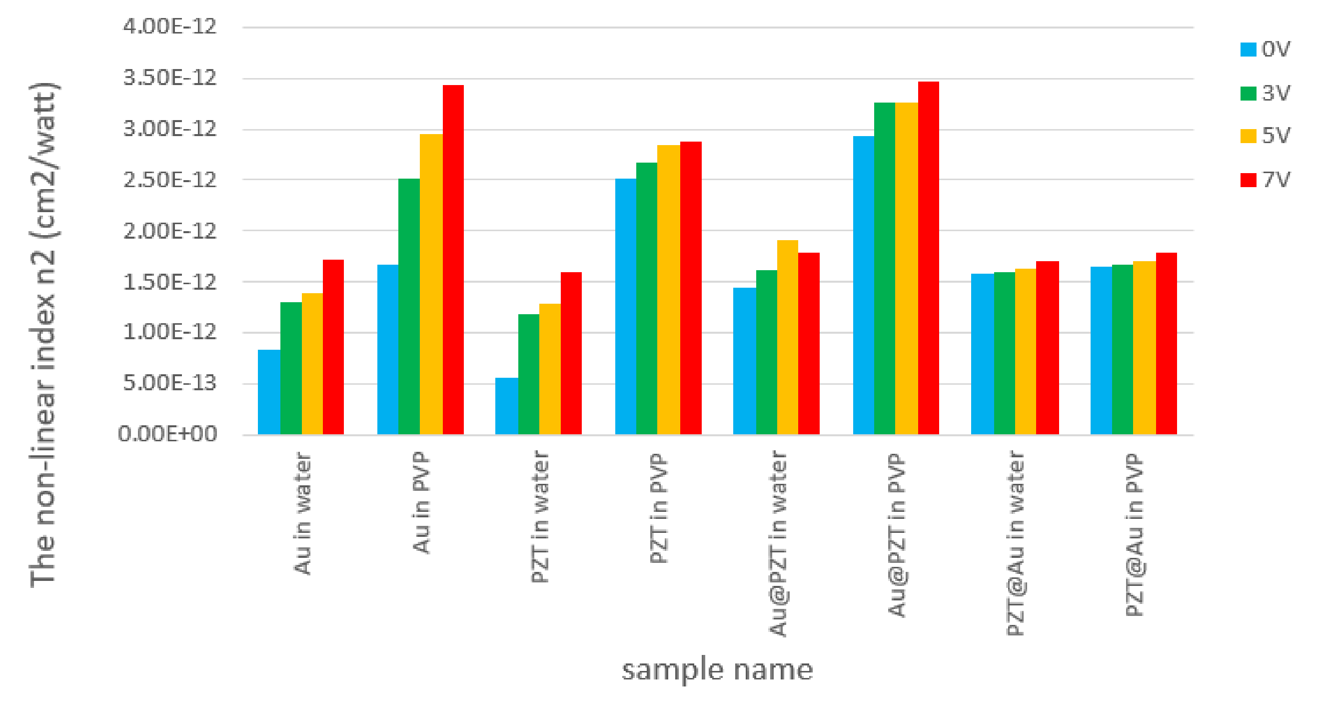
[Our new paper in](#)

nanotechnology journal

Congratulations to our new paper " Tunable Piezophotonic effect in core shell nanoparticles prepared by laser ablation in liquids under external voltag", by A.K. Kodeary, S. M. Hamidi.

We report an experimental study on the piezophotonic effect of gold and Lead Zirconate Titanate ($PbZrTiO_3$) nanoparticles
(NPs) and also core shell of them which prepared by laser ablation in liquid
method. To reach these NPs and composite materials, the targets immersed in
deionized water, and a polymeric solution of Poly vinyl pyrolidone (PVP) under
Nd: YAG laser pulses irradiation. Linear and non-linear properties of these NPs
were studied by optical spectroscopic and Z-scan technique. Furthermore,
tunable nonlinear properties of them was measured under external electric field
under light illumination to investigate the piezophotonic effect. Our results
show that at the interface of PZT and Au, due to the schottky barrier, we have
electron / hole recombination prevention which lead to the efficient
enhancement in the nonlinear properties.



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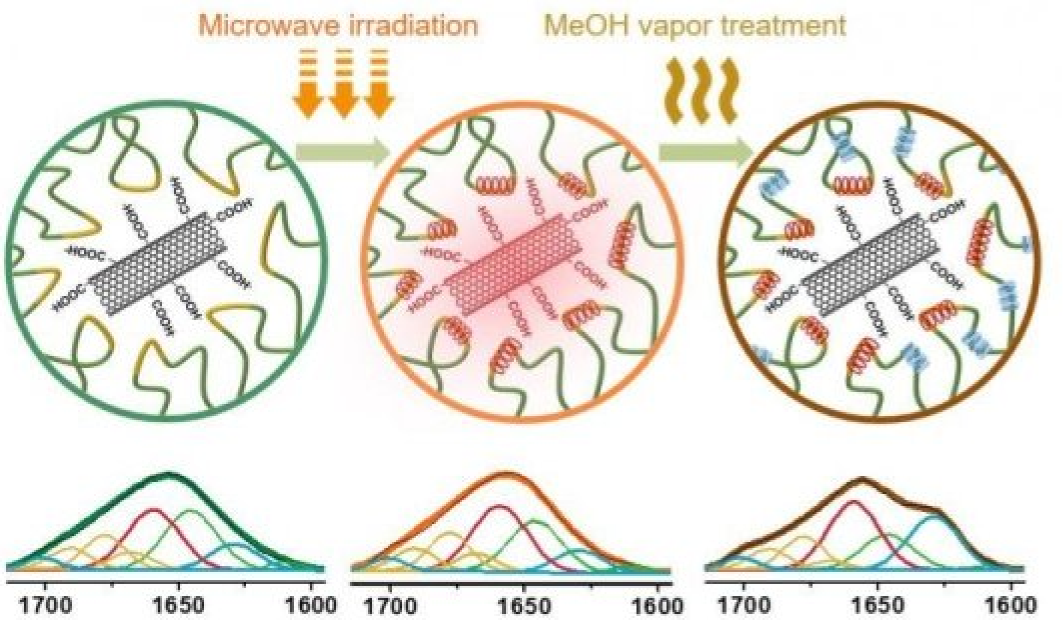
Making a transparent flexible material of silk and nanotubes

The silk fibers produced by Bombyx mori, the domestic silkworm, has been prized for millennia as a strong yet lightweight and luxurious material. Although synthetic polymers like nylon and polyester are less costly, they do not compare to silk's natural qualities and mechanical properties. And according to research from the University of Pittsburgh's Swanson School of Engineering, silk combined with carbon nanotubes may lead to a new generation of biomedical devices and so-called transient, biodegradable electronics.



"Silk is a very interesting material. It is made of natural fibers that humans have been using for thousands of years to make high quality textiles, but we as engineers have recently started to appreciate silk's potential for many emerging applications such as flexible bioelectronics due to its unique biocompatibility, biodegradability and mechanical flexibility," noted Mostafa Bedewy, assistant professor of industrial engineering at the Swanson School and lead author of the paper. "The issue is that if we want to use silk for such applications, we don't want it to be in the form of fibers. Rather, we want to regenerate silk proteins, called fibroins, in the form of films that exhibit desired optical, mechanical and chemical properties."

As explained by the authors in the video below, these regenerated silk fibroins (RSFs) however typically are chemically unstable in water and suffer from inferior mechanical properties, owing to the difficulty in precisely controlling the molecular structure of the fibroin proteins in RSF films. Bedewy and his NanoProduct Lab group, which also work extensively on carbon nanotubes (CNTs), thought that perhaps the molecular interactions between nanotubes and fibroins could enable “tuning” the structure of RSF proteins.

“One of the interesting aspects of CNTs is that, when they are dispersed in a polymer matrix and exposed to microwave radiation, they locally heat up,” Dr. Bedewy explained. “So we wondered whether we could leverage this unique phenomenon to create desired transformations in the fibroin structure around the CNTs in an “RSF-CNT” composite.”

According to Dr. Bedewy, the microwave irradiation, coupled with a solvent vapor treatment, provided a unique control mechanism for the protein structure and resulted in a flexible and transparent film comparable to synthetic polymers but one that could be both more sustainable and degradable. These RSF-CNT films have potential for use in flexible electronics, biomedical devices and transient electronics such as sensors that would be used for a desired period inside the body ranging from hours to weeks, and then naturally dissolve.

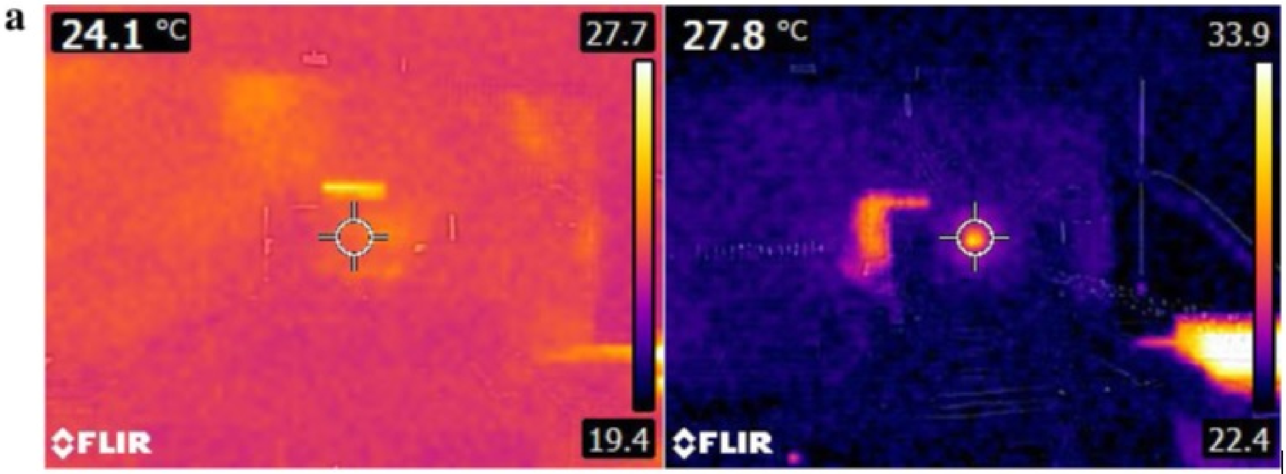
“We are excited about advancing this work further in the future, as we are looking forward to developing the science and technology aspects of these unique functional materials,” Dr. Bedewy said. ” From a scientific perspective, there is still a lot more to understand about the molecular interactions between the functionalization on nanotube surfaces and protein molecules. From an engineering perspective, we want to develop scalable manufacturing processes for taking cocoons of natural silk and transforming them into functional thin films for next generation wearable and implantable electronic devices.”

For more information: https://www.sciencedaily.com/releases/2018/10/181030121927.htm

Our new paper in Applied physics A

Congratulations to our new paper “Detecting the thermoplasmonic effect using ellipsometry parameters for self-assembled gold nanoparticles within a polydimethylsiloxane matrix” by Maher Abdulfadhil Gatea, Hussein A. Jawad,· S. M. Hamidi.

Light-to-heat conversion using active plasmonic materials is essential in wide-ranging applications, such as sensing, photonics, drug delivery, biomedical imaging, photothermal tumor therapy, and optoelectronics. In this work, we studied the thermoplasmonic effect and performed an optical analysis of different concentrations of self-assembled gold nanoparticles in transparent dielectric polydimethylsiloxane polymer medium under continuous-wave radiations. Composite samples were prepared and investigated experimentally by ellipsometry method and thermal photography. The gold-nanoparticle content of each composite film directly increased the generated temperature. The structure and optical properties of the samples under ambient conditions were obtained efficiently depending on the ellipsometry parameters for each polarized light. Results showed that the prolongation of the incubation time led to a lower phase value for p polarization than that for s polarization. This finding was due to the change in ellipsometry parameters and, thus, the thermoplasmonic effect. This new method of investigating the thermoplasmonic effect can provide new insights into the medical applications of
plasmonic media.

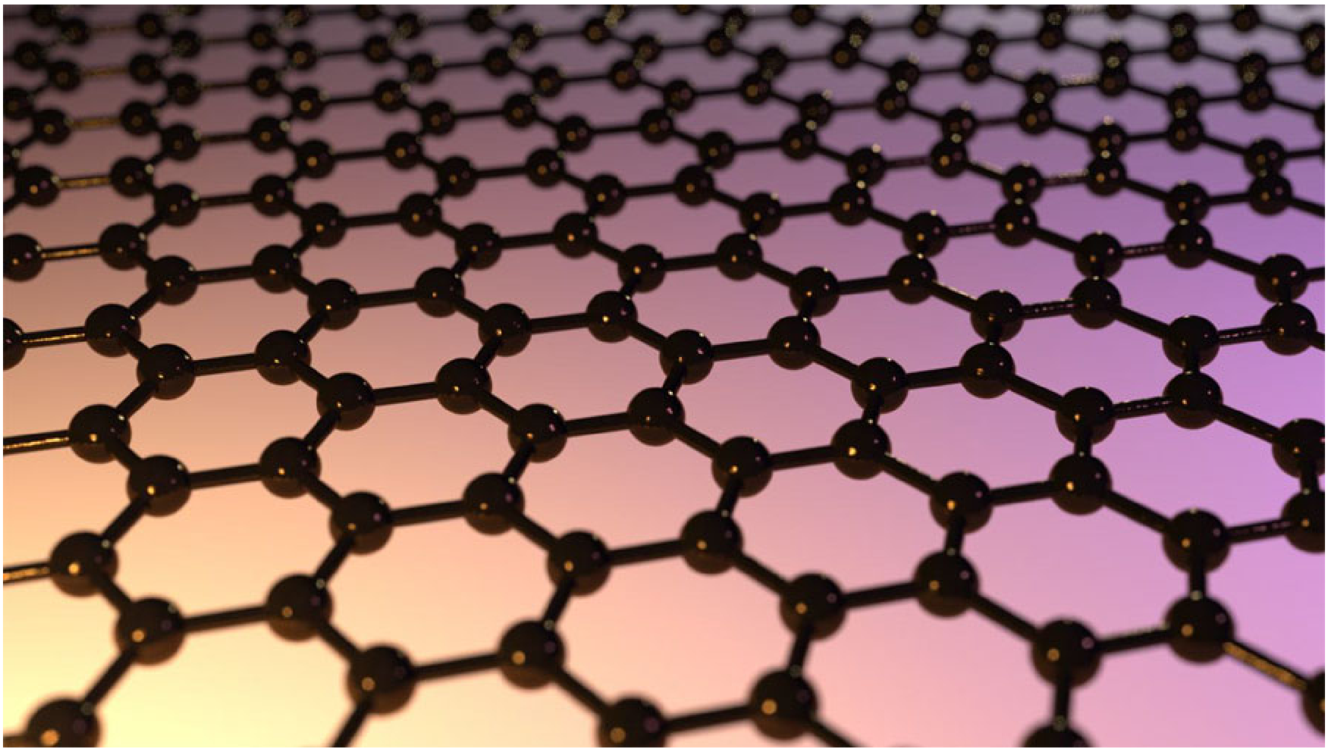


[Pure Graphene Generates Photocurrent Over Great Distances for Ultra-Efficient Energy Flow]

RIVERSIDE, Calif., Jan. 8, 2019 — An international research team has discovered a new mechanism for ultra-efficient charge and energy flow in pristine graphene. The team was co-led by professor Nathaniel Gabor from the University of California, Riverside.

The researchers fabricated graphene with no impurities (pristine graphene) into different geometric shapes, connecting narrow ribbons and crosses of graphene to rectangular regions of the material. They found that when light was shined on constricted areas of the graphene, a large photocurrent was created. The photocurrent occurred in a parameter regime that was different from previously observed photothermoelectric or photovoltaic photocurrents in graphene.

In the pristine graphene, the photocurrent emerged exclusively at the charge neutrality point.



Although graphene has been studied vigorously for more than a decade, new measurements on high-performance graphene devices have revealed yet another unusual property. In ultraclean graphene sheets, energy can flow over great distances, giving rise to an unprecedented response to light. Courtesy of Max Grossnickle and QMO Labs, UC Riverside.

"We found that photocurrents may arise in pristine graphene under a special condition in which the entire sheet of graphene is completely free of excess electronic charge," Gabor said. "Generating the photocurrent requires no special junctions and can instead be controlled, surprisingly, by simply cutting and shaping the graphene sheet into unusual configurations, from ladder-like linear arrays of contacts, to narrowly constricted rectangles, to tapered and terraced edges."

In most solar energy harvesting devices, a photocurrent arises only in the presence of a junction between two dissimilar materials, such as *p-n* junctions. The electrical current is generated in the junction region and moves through the distinct regions of the two materials. In the pristine graphene, the photocurrent emerged near the edges and corners of the material.

In principle, graphene can absorb light at any frequency, making it suitable for IR and other types of photodetection. The discovery that pristine graphene can convert light into electricity efficiently could lead to more efficient, faster [photodetector](#)s, and potentially more efficient solar panels.

The researchers have found evidence that the use of pristine graphene to generate photocurrent engenders a greatly enhanced photoresponse in the IR regime and results in ultrafast operation speeds. “We plan to further study this effect in a broad range of IR and other frequencies, and measure its response speed,” said researcher Qiong Ma from the Massachusetts Institute of Technology.

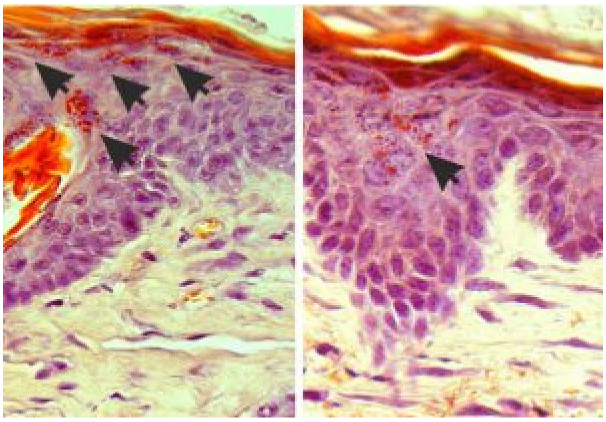
For more information:
https://doi.org/10.1038/s41565-018-0323-8

Using Light to Stop Itch

Could Provide Relief From Skin Diseases

ROME, Jan. 3, 2019 — Scientists at the European Molecular Biology Laboratory (EMBL) in Rome have used light to stop itch — at best an annoyance and at worst an uncomfortable chronic symptom — in mice. They used NIR light to activate a phototoxic agent that selectively targets itch-sensing cells, which are located in the upper surface of the skin. When the agent is injected into a mouse's affected skin area and the area is illuminated with the NIR light, the itch-sensing cells withdraw from the skin, reducing itch-associated behaviors in the mouse and allowing the skin to heal. The researchers said that the effect of the treatment can last several months.

The light-sensitive agent binds only to those nerve cells that sense itch. Other types of nerve cells in the skin, which cause sensations like pain, vibration, cold, or heat, are not affected by the light treatment.



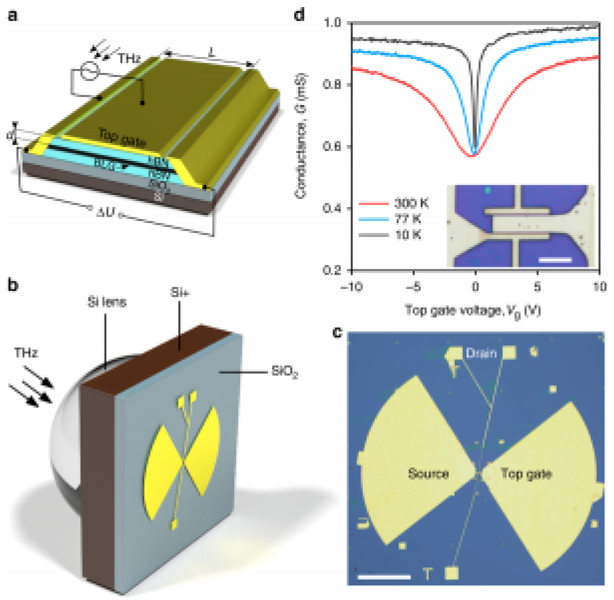
The researchers said that the method works well in mice with eczema (atopic dermatitis) and in mice with amyloidosis (familial primary localized cutaneous amyloidosis), a genetic skin disease for which there is currently no cure. "For me, the most exciting part of this project was seeing the improvements in the animals' health," said researcher Linda Nocchi. "Their skin looked much better after treatment and they scratched less." "We hope that one day, our method will be able to help humans suffering from a disease like eczema, which causes chronic itching," said group leader Paul Heppenstall. It is already known that mice and humans have the same target molecule for itch therapy – a small protein called interleukin 31 (IL-31). One of the team's next steps will be to test the light therapy in human tissues.

Previously, the Heppenstall group published a method to manage chronic pain with light. "We think that the mechanism we've discovered might be a general method for controlling sensation through the skin. Our goal now is to take these therapies further. We want to collaborate with industry partners to develop therapies for humans, but also for veterinary medicine, as itch is a major problem in dogs as well," Heppenstall said.

For more information: https://doi.org/10.1038/s41551-018-0328-5

Resonant terahertz detection using graphene plasmons

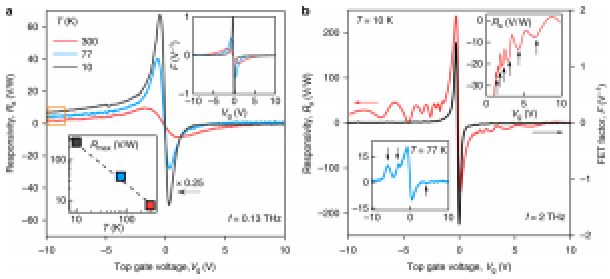
Plasmons, collective oscillations of electron systems, can efficiently couple light and electric current, and thus can be used to create sub-wavelength photodetectors, radiation mixers, and on-chip spectrometers. Despite considerable effort, it has proven challenging to implement plasmonic devices operating at terahertz frequencies. The material capable to meet this challenge is graphene as it supports long-lived electrically tunable plasmons. Here we demonstrate plasmon-assisted resonant detection of terahertz radiation by antenna-coupled graphene transistors that act as both plasmonic Fabry-Perot cavities and rectifying elements. By varying the plasmon velocity using gate voltage, we tune our detectors between multiple resonant modes and exploit this functionality to measure plasmon wavelength and lifetime in bilayer graphene as well as to probe collective modes in its moiré minibands. Our devices offer a convenient tool for further plasmonic research that is often exceedingly difficult under non-ambient conditions (e.g. cryogenic temperatures) and promise a viable route for various photonic applications.



Graphene-based THz detectors. **a** Schematics of the encapsulated BLG FET used in this work. **b** 3D rendering of our resonant photodetector. THz radiation is focused to a broadband bow-tie antenna by a hemispherical silicon lens yielding modulation of the gate-to-source voltage, as indicated in **a**. **c** Optical photograph of one of our photodetectors. Scale bar is 200 µm. **d** Conductance of one of our BLG FETs as a function of the gate voltage V_g, measured at a few selected temperatures. Inset: zoomed-in photograph of **c** showing a two-terminal FET with gate and source terminals connected to the antenna. Scale bar is 10 µm.

Broadband operation

We intentionally start the photoresponse measurements at the low end of the sub-THz domain, where the plasma oscillations are overdamped (see below). This allows us to compare the performance of our detectors with previous reports.



Plasmon-assisted THz photodetection. **a** Responsivity measured at *f* = 130 GHz and three representative temperatures. Orange rectangle highlights an offset stemming from the rectification of incident radiation at the p-n junction between the p-doped graphene channel and the n-doped area near the contact. Upper inset: FET-factor *F* as a function of V_g at the same *T*. Lower inset: maximum R_a as a function of *T*. **b** Gate dependence of responsivity recorded under 2 THz radiation. The upper inset shows a zoomed-in region of the photovoltage for electron doping. Resonances are indicated by black arrows. Lower inset: resonant responsivity at liquid-nitrogen temperature.

Resonant responsivity is a universal phenomenon in ultra-clean graphene devices and is expected to be independent of the physical mechanisms behind the rectification of the ac field into a dc photovoltage. Nevertheless, it is important to establish possible nonlinearities responsible for the rectification, for example, in order to be able to increase the magnitude of responsivity. We first note that the aforementioned asymmetry in R_a (V_g) between electron and hole doping indicates rectification at the *p*–*n* junction formed in vicinity of the contacts. This rectification usually appears due to the thermoelectric effect arising as a result of non-uniform sample heating and the difference between the Seebeck coefficients in the graphene channel and contact regions.

For more information: https://www.nature.com/articles/s41467-018-07848-w