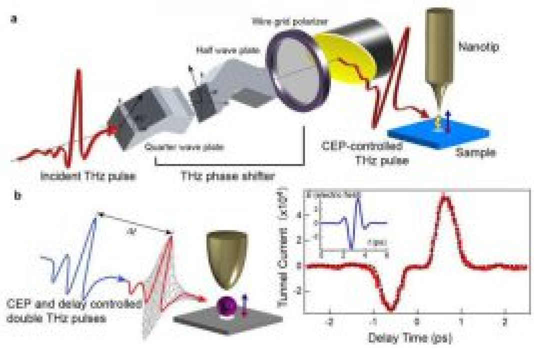
Light switch: Scientists develop method to control nanoscale manipulation in high-powered microscopes

Researchers from Japan have taken a step toward faster and more advanced electronics by developing a a better way to measure and manipulate conductive materials through scanning tunneling microscopy. The team published their results in July in *Nano Letters*, an American Chemical Society journal. Scientists from the University of Tokyo, Yokohama National University, and the Central Research Laboratory of Hamamatsu Photonics contributed to this paper.



Scanning tunneling microscopy (STM) involves placing a conducting tip close to the surface of the conductive material to be imaged. A voltage is applied through the tip to the surface, creating a “tunnel junction” between the two through which electrons travel. The shape and position of the tip, the voltage strength, and the conductivity and density of the material’s surface all come together to provide the scientist with a better understanding of the atomic structure of the material being imaged. With that information, the scientist should be able to change the variables to manipulate the material itself. The researchers designed a custom terahertz pulse cycle that quickly oscillates between near and far fields within the desired electrical current.

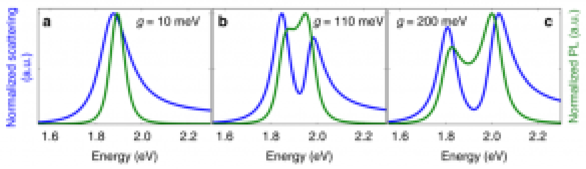
“The characterization and active control of near fields in a tunnel junction are essential for advancing elaborate manipulation of light-field-driven processes at the nanoscale,” said Jun Takeda, a professor in the department of physics in the Graduate School of Engineering at Yokohama National University. “We demonstrated that desirable phase-controlled near fields can be produced in a tunnel junction via terahertz scanning tunneling microscopy with a phase shifter.”

According to Takeda, previous studies in this area assumed that the near and far fields were the same—spatially and temporally. His team examined the fields closely and not only identified that there was a difference between the two, but realized that the pulse of fast laser could prompt the needed phase shift of the terahertz pulse to switch the current to the near field.

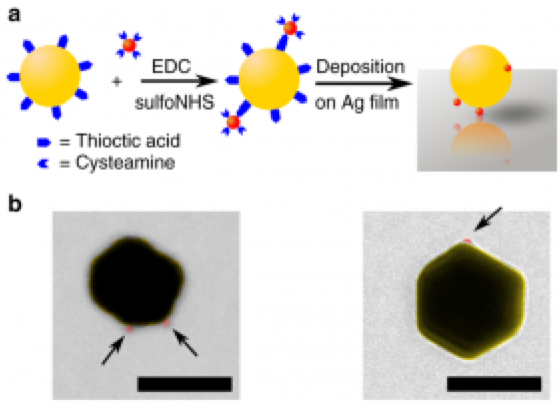
More information: Katsumasa Yoshioka et al, Tailoring Single-Cycle Near Field in a Tunnel Junction with Carrier-Envelope Phase-Controlled Terahertz Electric Fields, *Nano Letters* (2018). DOI: 10.1021/acs.nanolett.8b02161

Strong coupling and induced transparency at room temperature with single quantum dots and gap plasmons

Coherent coupling between plasmons and transition dipole moments in emitters can lead to two distinct spectral effects: vacuum Rabi splitting at strong coupling strengths, and induced transparency (also known as Fano interference) at intermediate coupling strengths. Achieving either strong or intermediate coupling between a single emitter and a localized plasmon resonance has the potential to enable single-photon nonlinearities and other extreme light–matter interactions, at room temperature and on the nanometer scale. Both effects produce two peaks in the spectrum of scattering from the plasmon resonance, and can thus be confused if scattering measurements alone are performed. Here we report measurements of scattering and photoluminescence from individual coupled plasmon–emitter systems that consist of a single colloidal quantum dot in the gap between a gold nanoparticle and a silver film. The measurements unambiguously demonstrate weak coupling (the Purcell effect), intermediate coupling (Fano interference), and strong coupling (Rabi splitting) at room temperature.



As shown in Fig. , however, a measurement of the photoluminescence (PL) spectrum can distinguish between the two regimes. Unlike scattering, PL is an incoherent process, and thus does not display Fano interference. Splitting in the PL spectrum thus occurs only in the strong-coupling regime, and has therefore been recognized as the definitive signature of Rabi splitting. So far, there has been only one report of PL splitting for a single emitter (a QD) coupled to a plasmonic metal nanostructure, but the PL spectrum showed an unexpected four-peak structure.



Fabrication of coupled quantum-dot / gap-plasmon systems. a Illustration of the synthesis process. Quantum dots (red) are linked to gold nanoparticles (yellow) through their capping molecules. The linked assemblies are then deposited on a silver film. b Electron-microscope images of linked assemblies. Quantum dots are colored in red and indicated by arrows. The left image was obtained by scanning transmission electron microscopy, and the right image was obtained by transmission electron microscopy. The scale bars are 100 nm

For more information: https://www.nature.com/articles/s41467-018-06450-4

[Impact of pump wavelength on terahertz emission of a

cavity-enhanced spintronic trilayer

We systematically study the pump-wavelength dependence of terahertz pulse generation in thin-film spintronic THz emitters composed of a ferromagnetic Fe layer between adjacent nonmagnetic W and Pt layers. We find that the efficiency of THz generation is essentially flat for excitation by 150 fs pulses with center wavelengths ranging from 900 to 1500 nm, demonstrating that the spin current does not depend strongly on the pump photon energy. We show that the inclusion of dielectric overlayers of TiO2 and SiO2, designed for a particular excitation wavelength, can enhance the terahertz emission by a factor of of up to two in field.

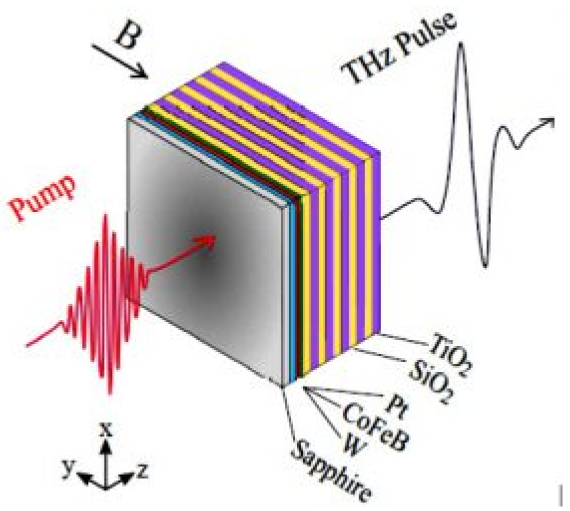


FIG. 1: Schematic of a spintronic trilayer with added dielectric cavity, grown on 0.5 mm of sapphire (Al2O3). The near-infrared pump pulse, incident through the substrate, is partially absorbed in the metallic layers, launching a spin current from the ferromagnetic (FM) layer into the nonmagnetic (NM) layers. The inverse spin Hall effect converts this ultrashort out-of-plane spin current into an in-plane charge current resulting in the emission of THz radiation into the optical far-field. A weak in plane magnetic field (B) determines the magnetization direction, and the linear

polarization of the emitted THz field.

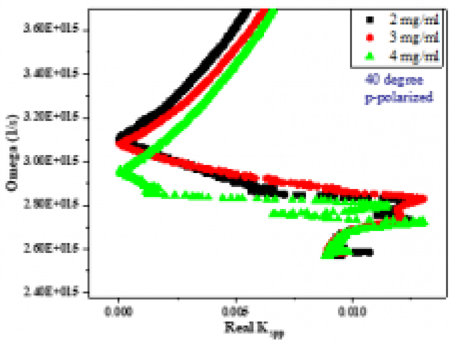
For more information: https://arxiv.org/abs/1808.00746

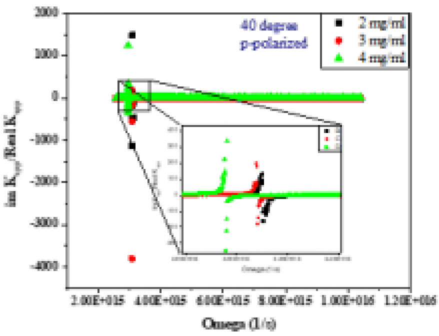
Our new paper in Superlattices and microstructures

Congratulations for the publication of paper " Fantastic Exciton-plasmon coupling in Dye-doped Poly (vinyl pyrrolidone) /Gold one-dimensional Nano-grating "

By Asgari, S. M. Hamidi

The present study aimed to investigate the coupling between the exciton in dye medium and plasmon in gold nano-grating. To this aim, at first, Polyvinylpyrrolidone (Rhodamine B) /Gold nano-grating samples were prepared with different concentrations and thicknesses of dye layer. Then, the spectroscopy of the selected samples was conducted under incident angle modulations and the dispersion diagrams were plotted based on the reflectance spectra. The results revealed the formation of new extra plexcitonic modes as a coupling between exciton and plasmon in the dispersion relation of samples. These new extra modes can be adjusted through the concentrations of the dye layer, the thickness of which is very useful for next generation of plexcitonic devices.

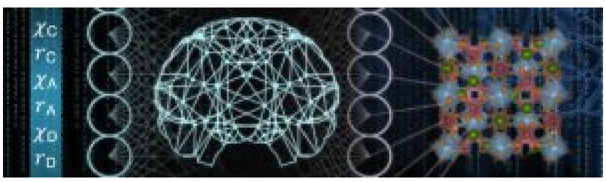




[Neural Networks Predict Crystal Stability]

SAN DIEGO, Sept. 21, 2018 — Researchers at the University of California, San Diego (UCSD) are using neural networks to predict the stability of materials in two classes of crystals: garnets and perovskites.

They trained artificial neural networks to predict a crystal's formation energy using just two inputs: electronegativity and ionic radius of the constituent atoms. Based on this work, they developed models that can identify stable materials in two classes of crystals. According to the team, its models are up to 10× more accurate than previous machine learning models and are fast enough to efficiently screen thousands of materials in a matter of hours on a laptop.



"Garnets and perovskites are used in LED lights, rechargeable lithium-ion batteries, and solar cells. These neural networks have the potential to greatly accelerate the discovery of new materials for these and other important applications," said researcher Weike Ye.

The team has made their models publicly accessible via a web application at http://crystals.ai so that others can use the neural networks to compute the formation energy of any garnet or perovskite composition on the fly.

"Predicting the stability of materials is a central problem in materials science, physics and chemistry," said professor Shyue Ping Ong. "On one hand, you have traditional chemical intuition such as Linus Pauling's five rules . . . On the other, you have expensive quantum mechanical computations to calculate the energy gained from forming a crystal . . . What we have done is to use artificial neural networks to bridge these two worlds."

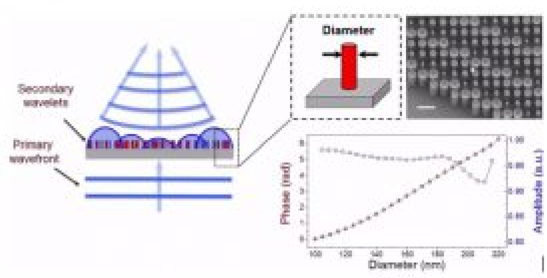
For more information: doi:10.1038/s41467-018-06322-x

Flat optics: from high-performance metalenses to structured light

In this keynote presentation, Federico Capasso, professor of applied physics at Harvard University, presents advances in dielectric metalenses in the visible, which correct spherical, coma, and chromatic aberrations.

Capasso begins his talk by reminding the audience that conventional lenses still require a very complex type of

technology as it takes several lenses to correct aberrations. “Basically, it’s 19th century technology perfected for the 21st century,” says Capasso. “So it’s really polishing, grinding, and so forth with some really expensive machines.”
Capasso describes metaoptics as a different way of looking at diffractive optics. “Metalenses have advantages over traditional lenses,” says Capasso, noting that metalenses are thin, easy to fabricate, and cost effective, and these advantages extend across the whole visible range of light.



Principle of metalenses: Controlling wavefront using nanostructures.

The metalenses developed by Capasso and his team use arrays of titanium dioxide nanofins to equally focus wavelengths of light and eliminate chromatic aberration. The metalenses are designed to provide spatially dependent group delays such that wavepackets from different locations arrive simultaneously at the focus and with the same width.
Metalens research seeks to achieve wavefront shaping of light using optical elements with thicknesses on the order of the wavelength. This miniaturization could to lead to compact, nanoscale optical devices with applications in cameras, lighting, displays, and wearable optics.

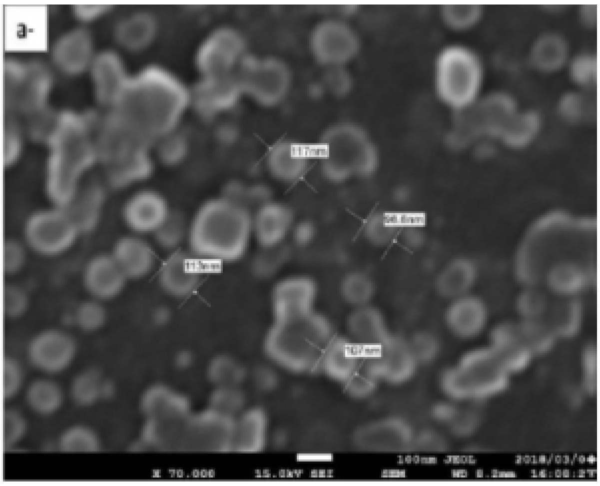
For more information: http://spie.org/newsroom/pw18_plenaries/pw18_capasso-

Our new paper in Sylwan Nano Journal

Congratulations for the publication of paper"Thermoplasmonic response of Au@SiO2 core–shell nanoparticles in deionized water and poly-vinylpyrrolidone matrix"

Maher Abdulfadhil Gatea, Hussein A. Jawad, M. Mosleh, S. M. Hamidi

Metal-dielectric core–shell nanoparticles strongly absorb light and convert into an efficient localized heat source in the presence of electromagnatic radiation at their plasmonic resonance. This process can be enhanced depending on the size, shape, structure, and surrounding media. This study theoretically and experimentally investigated the thermoplasmonic effects of Au@SiO2 core–shell nanoparticles immersed in water and poly-vinylpyrrolidone prepared through laser ablation in liquid. Two lasers (532 nm cw Nd:YAG and 520 nm fs pulsed ytterbium fiber) were used to illuminate the prepared samples. The theoretical thermoplasmonic response of the samples was estimated based on the finite element method of COMSOL multiphysics V5.2a. The generated heat difference of Au@SiO2 in both media with fs pulsed laser irradiation was higher than that of cw laser regarding the power used due to the heat confinement during the time of the pulse that cannot be disspated. This study can serve as a basis for using plasmonic core–shell nanoparticles as a nanoheat source in medical applications.

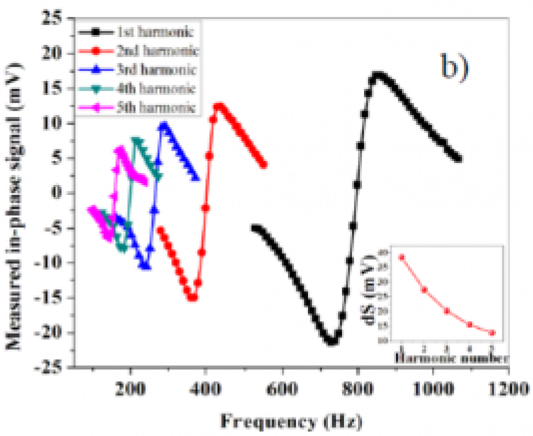


Our new paper in Journal of magnetism and magnetic materials

Congratulations for the publication of paper "Relaxation time dependencies of optically detected magnetic resonance harmonics in highly sensitive Mx magnetometers"

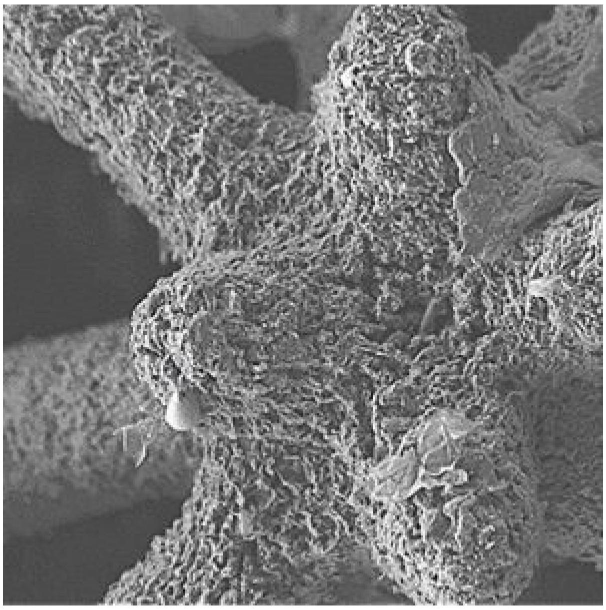
Ranjbaran, M.M. Tehranchi, S.M. Hamidi, S.M.H. Khalkhali

Measurement of extremely weak magnetic fields in double-resonance atomic magnetometers based on resonant optical excitation has been an active area of research in recent years. Magnetometer sensitivity can be improved via detection of higher harmonics of the magnetic resonance, a resonance which has a maximum sensitivity under conditions where the ratio of the amplitude to the line-width of the resonance signal is maximized. Based on the Bloch theorem, we analyze the time evolution of the spin polarization corresponding to each harmonic component of the resonance signal and measure this progression experimentally. Our results revealed that there is an optimal harmonic number for achieving the highest sensitivity. We have shown that the longitudinal and transverse relaxation times of spin polarization can manipulate the harmonics with the best sensitivity while the excitation frequency is detuned from the Larmor frequency.



[3-D Printing Graphene Aerogels]

A U.S. research team from Virginia Tech and the Lawrence Livermore National Lab (LLNL) has demonstrated a light-based approach for 3-D printing strong, lightweight, porous graphene aerogels—at a resolution an order of magnitude finer than other techniques. 3-D printing is well advanced for polymer foams, with some notable success, but is still an active area of research for graphene foams. Researchers have published schemes for printing 3-D graphene using a number of approaches, such as extrusion. As a result, according to the researchers, these techniques have generally printed out 3-D graphene structures with relatively weak, bending-dominated configurations, such as stacked "woodpile" structures, and relatively large achievable feature sizes (greater than 100 microns). That’s a far cry, they say, from the high-resolution, complex structures that could open up applications in areas such as energy storage and conversion.



In particular, they opted for a form of 3-D printing called projection micro-stereolithography (PμSL)—a light-based technique that allows the resin feeding the 3-D printing process to be shaped into fine-scale, intricate forms via patterned light. Using this technique, an entire layer of 3-D-printing resin can be cured, at very fine scales, via a single UV flash. That advantage, the team reasoned, could potentially overcome some of the toolpath and sequence issues experienced by other approaches to 3-D printing of graphene. The big trick was to figure out a way to make a photocurable graphene resin—one that would quickly firm up under a light beam, but that also was sufficiently runny to be slathered layer by layer on the workpiece. To get there, Hensleigh spent some time in the chemistry lab, developing a porous graphene-oxide hydrogel with cross-linked sheets, and then using ultrasound to disperse the cross-linked graphene oxide into a dilute, 1-weight-percent suspension.

The result is exquisite, intricate, airy structures, such a lattices of octet trusses, with feature sizes on the order of 10 microns—an order of magnitude finer, according to the team, than other 3-D-printed graphene structures. They're lightweight enough to balance on a single filament of a strawberry blossom (see image at top of story). And they're also strong; as measured by their Young's modulus, the strength of the PμSL-printed structures seems to hold up better than that of most other 3-D graphenes and other carbon aerogels as the density of the structure decreases.

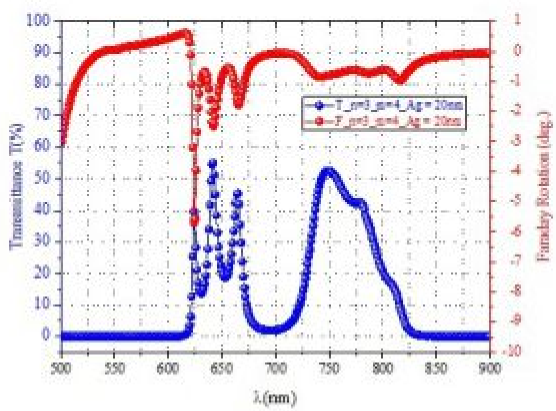
For more information: doi: [10.1039/C8MH00668G](10.1039/C8MH00668G)

[Our new paper in Journal of magnetism and magnetic materials]()

Congratulations for the publication of paper "*Faraday rotation in a coupled resonator magneto-plasmonic structure Tamm plasmon boosting*"

M. Hamidi, R. Moradlou

The present study aimed to evaluate the magneto-optic Faraday rotation of one-dimensional coupled resonator magnetoplasmonic structure by metallic cover layer in each resonator. To this purpose, transfer matrix method was used where SiO_2 and Bismuth substitute garnet thin films playing main building block and the gold or silver layer use to reach $((SiO_2/\ Bi{:}YIG)^n\ /(Au$ or $Ag)/\ SiO_2)^m$ structure; where n and m are considered as the repetition and resonator numbers, respectively. Tamm plasmons related to the phase cancelation in photonic band gap are identified by optical and magneto-optical spectra and accordingly the phase change in the structure. Based on these modes, a wide range of wavelengths is detected by which the figure of merit increases due to the interaction of light with Tamm plasmons and surprisingly the flat optical window in this region in addition to the main resonance. These structures can open a new gate for enhancing performance of the magneto-optic devices.



For more information: https://doi.org/10.1016/j.jmmm.2018.08.083