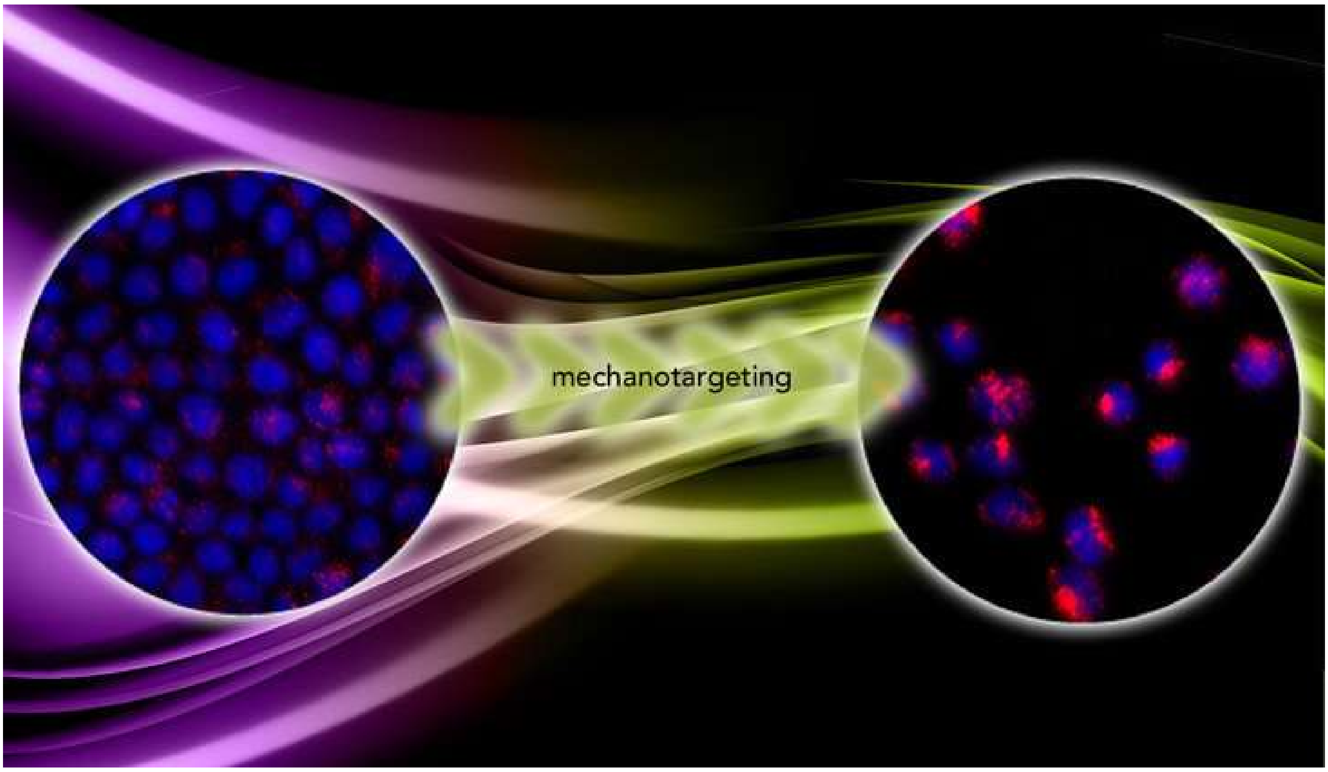
Targeting strategy may open door to better cancer drug delivery

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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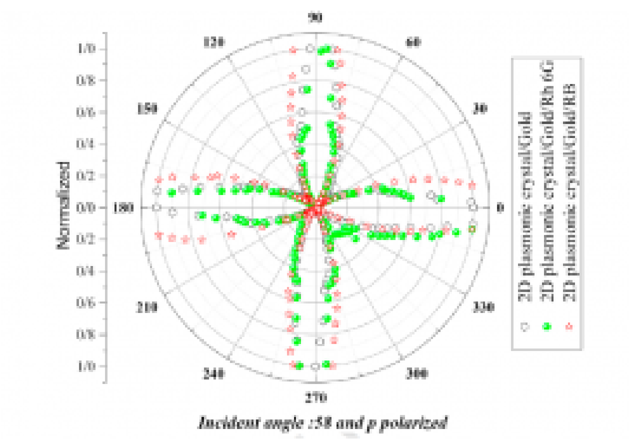
Our New Paper in Optical Materials

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.



Opto-thermoelectric nanotweezers

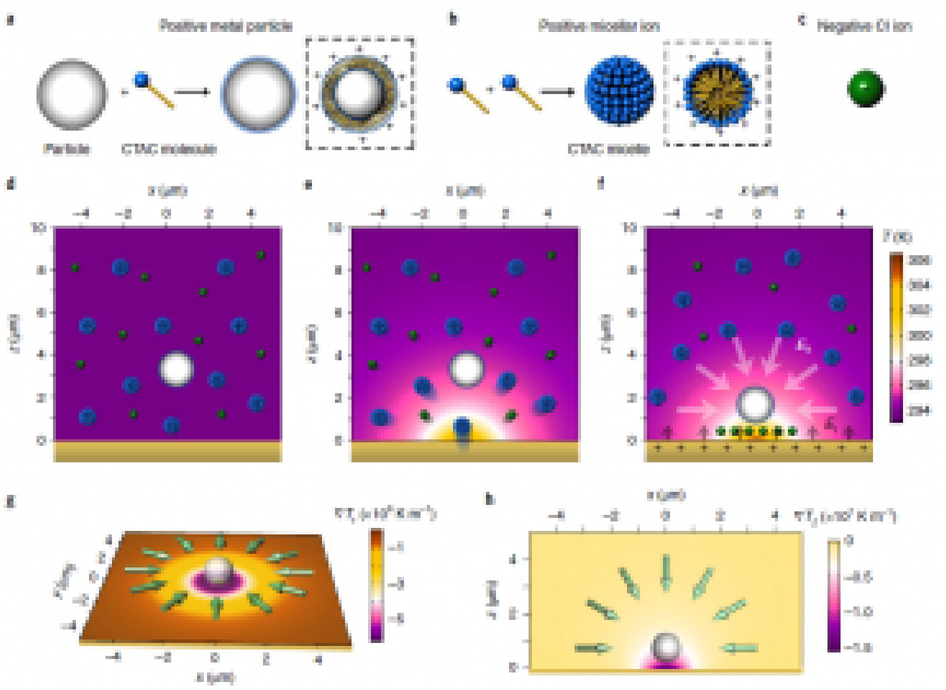


Fig. 1 | Working principle of OTENT. **a**, Surface charge modification of a metal nanoparticle by CTAC adsorption. **b**, Formation of CTAC micelles. **c**,Schematic view of a Cl− ion. **d**, Dispersion of a single metal particle and multiple ions in the solution without optical heating. **e**, Thermophoretic migrationof the ions under optical heating. **f**, Steady ionic distribution under optical heating generates a thermoelectric field *E*T for trapping the metal nanoparticle.The repulsive electric field *E*r arises from the positive charges of thethermoplasmoic substrate and balances *E*T. **g**, Simulated in-plane temperature gradient ∇*T*r and direction of the corresponding trapping force. **h**, Simulated out-of-plane temperature gradient ∇*Tz* and direction of the corresponding trappingforce. The incident laser beam in **e**–**h** has a diameter of 2 μ m and an optical power of 0.216 mW. The green arrows in **g** and **h** show the direction of the trapping force.

Optical manipulation of plasmonic nanoparticles provides opportunities for fundamental and technical innovation in nanophotonics.Optical heating arising from the photon-to-phonon conversion is considered as an intrinsic loss in metal nanoparticles, which limits their applications. this group show that this drawback can be turned into an advantage, by developing an extremely low-power optical tweezing technique, termed opto-thermoelectric nanotweezers. By optically heating a thermoplasmonic substrate, a light-directed thermoelectric field can be generated due to spatial separation of dissolved ions within the heating laser spot, which allows us to manipulate metal nanoparticles of a wide range of materials, sizes and shapes with single-particle resolution. In combination with dark-field optical imaging, nanoparticles can be selectively trapped and their spectroscopic response can be resolved in situ. With its simple optics, versatile low-power operation, applicability to diverse nanoparticles and tunable working wavelength, opto-thermoelectric nanotweezers will become a powerful tool in colloid science and nanotechnology.

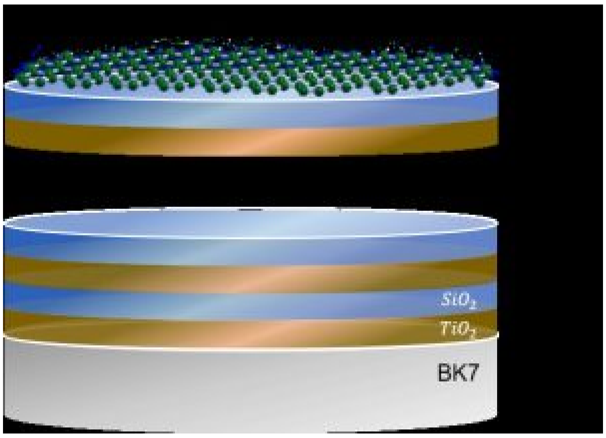
more information on:

[1]	M. W. X. P. E. N. L. Z. M. Linhan Lin1, “Opto-thermoelectric nanotweezers,” *nature photonics,* vol. 12, pp. 195-201, 2018, https://doi.org/10.1038/s41566-018-0134-3.

[Our new paper in Optical and

[Quantum electronics]

Congratulations for the publication of paper" Demonstration of tunable complex refractive index of graphene covered one dimensional photonic crystals", in journal of optical and quantum electronics, by S. M. Hamidi, M. Mahboubi, S. M. Mohseni, B. Azizi, A. Ghaderi, S. Javadi.



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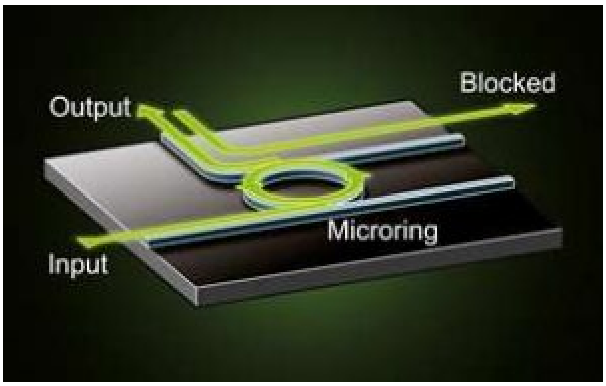
[Scientists create diodes made of light]



Photonics researchers at the National Physical Laboratory

(NPL) have achieved the extra-ordinary by creating a diode consisting of light that can be used, for the first time, in miniaturised photonic circuits, as published in Optica.

Dr. Pascal Del'Haye and his team at NPL have created an optical version of a diode that transmits light in one direction only, and can be integrated in microphotonic circuits. This small-scale integration has been a major challenge in photonics because existing optical diodes require bulky magnets.

NPL's ground-breaking work has overcome the limitation of diodes based on bulky magnets, by using light stored in tiny chip-based glass rings to form a diode.

Diodes are well known in electronic circuits. They transmit electric current in one direction but block the current in the backward direction. Diodes are essential components of nearly every electronic circuit and are used, for example, in battery chargers.

The novel technique was created by sending lots of light into a microresonator – a glass ring on a silicon chip, about the width of a human hair – and harnessing the circulating optical power to generate the diode effect.

Dr. Jonathan Silver, Higher Research Scientist at NPL, explains: "To create the optical diodes we used microrings that can store extremely large amounts of light. This meant that, even though we were only sending small amounts of light into these glass rings, the circulating power was comparable to the light generated by the flood lights in a whole football stadium—but confined into a device smaller than a human hair. The light intensities enable the formation of a diode via a light-with-light interaction called the Kerr effect."

In their experiments, they have shown that the electromagnetic field of clockwise circulating light in these glass rings effectively blocks any counterclockwise circulating light.

Pascal Del'Haye, Principal Research Scientist of the project emphasises: “These diodes will, for the first time, open the door to cheap and efficient optical diodes on microphotonic chips, and will pave the way for novel types of integrated photonic circuits which could be used for optical computing.

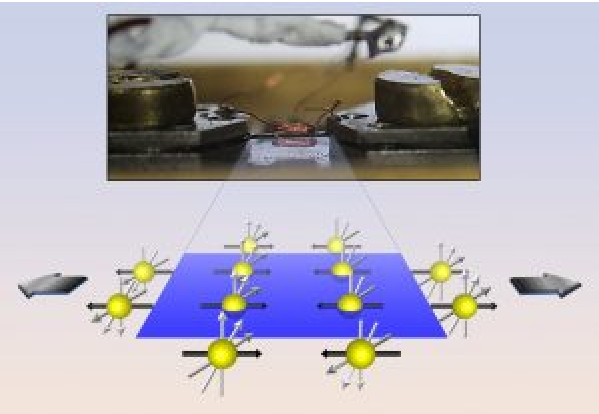
“They could also have significant impact on future optical telecommunication systems, for more efficient use of telecom networks.”

Leonardo Del Bino, Doctoral Student on the project, said: “A remarkable property of this novel diode is that the performance improves if the forward propagating light field is increased. This is very important, for example, when using the diode to protect chip-integrated laser diodes from back reflections.”

Beyond the use for optical diodes, NPL's research on interaction of counterpropagating light can enable new types of optical rotation sensors and optical memories.

More information: Leonardo Del Bino et al. Microresonator isolators and circulators based on the intrinsic nonreciprocity of the Kerr effect, Optica (2018). DOI: 10.1364/OPTICA.5.000279

[Piezomagnetic material changes magnetic properties when stretched]



Piezoelectric materials, which generate an electric current when compressed or stretched, are familiar and widely used: think of lighters that spark when you press a switch, but also microphones, sensors, motors and all kinds of other devices. Now a group of physicists has found a material with a similar property, but for magnetism. This “piezomagnetic” material changes its magnetic properties when put under mechanical strain.

“Piezomagnetic materials are rarely found in nature, as far as I’m aware,” said Nicholas Curro, professor of physics at UC Davis and senior author of a paper on the discovery published March 13 in the journal Nature Communications.

Curro and colleagues were studying a barium-iron-arsenic compound, BaFe2As2, that can act as a superconductor at temperatures of about 25 Kelvin when doped with small amounts of other elements. This type of iron-based superconductor is interesting because although it has to be kept pretty cold to work, it could be stretched into wires or cables.

BaFe2As2 is what is called a “nematic” crystal because its structure goes through a phase transition before it becomes superconducting. In the case of BaFe2As2, its crystal structure goes from a square to a rectangular configuration.

Curro and graduate students Tanat Kissikov and Matthew Lawson were attempting to study the material by nuclear magnetic resonance (NMR) imaging while stretching it, to see if they could force it into the rectangular configuration. To their surprise, the magnetic properties of $BaFe_2As_2$ changed as they stretched it.

The material is not a bulk magnet – the spins of its atoms point in alternating opposite directions, making it an antiferromagnet. But the direction of those magnetic spins does change in a measurable way when under stress, they found.

"The real surprise is that it appears that the direction of magnetism can change and come out of plane," Curro said.

At this point, there's no theory to explain these results, Curro said. His lab is looking to see if other materials can show the same behavior and if mechanical strain can affect the superconducting properties of the material (these experiments were not carried out at temperatures where $BaFe_2As_2$ is a superconductor).

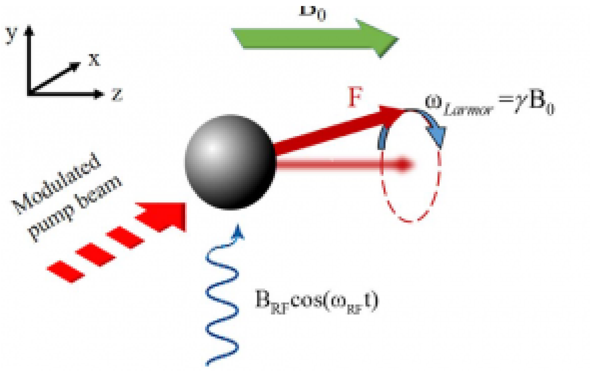
The discovery could have applications in new ways to look for strain within materials such as aircraft components, Curro said.

More information: T. Kissikov et al, Uniaxial strain control of spin-polarization in multicomponent nematic order of $BaFe_2As_2$, Nature Communications (2018). DOI: 10.1038/s41467-018-03377-8

Our new paper in physica C

Congratulations for the publication of paper"Sensitivity optimization of Bell-Bloom magnetometers by manipulation of atomic spin synchronization", in journal of Physica C, by

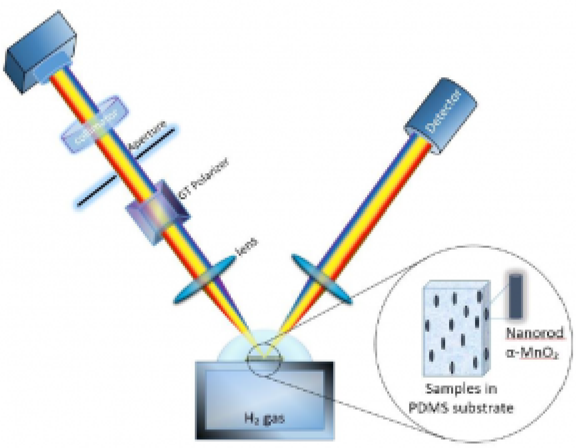
Malihe Ranjbaran, Mohammad Mehdi Tehranchi, Seyedeh Mehri Hamidi, Mohammad Hossein Khalkhali.



Read more at:

https://www.sciencedirect.com/science/article/pii/S0921453417302460

[Our new paper in Applied Physics A]

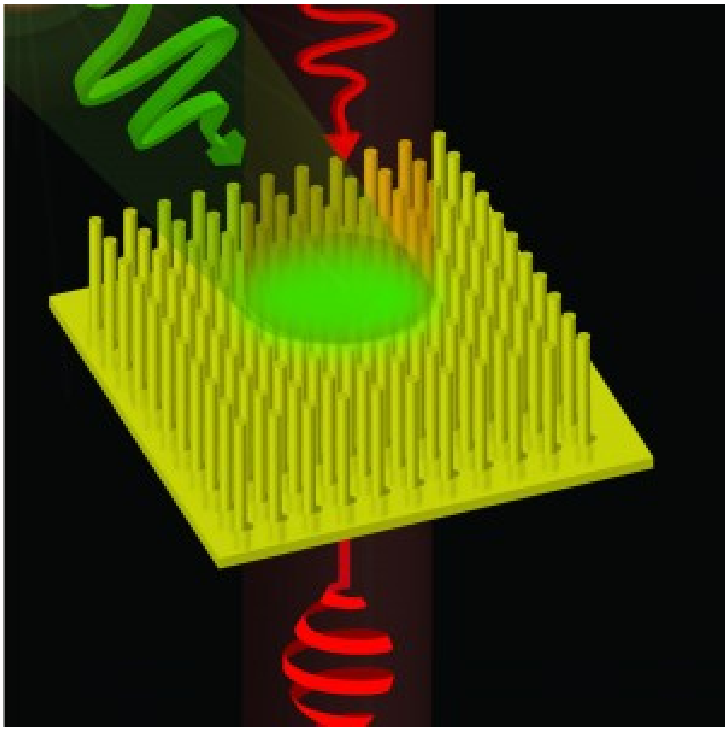


Congratulations for the publication of paper"New generation of α-MnO2 Nanowires @PDMS composite as a Hydrogen gas sensor", in journal of Applied Physics A, by Seyedeh Mehri Hamidi1,

Alireza Mosivand1, Mina Mahbobi1, Hadi Arabi, Narin Azad, Murtada Riyadh Jamal.

Abstract—New hydrogen gas sensor has been prepared by α-MnO_2 nanowires in polydimethylsiloxane matrix. For this purpose, the high aspect ratio α-MnO_2 nanowires has been prepared by the aid of Hydrothermal method and then dispersed into Poly-dimethyl siloxane polymer media. In order to gas sensing, the samples have been exposed under different gas concentrations from 0 to 5%. The sensor responses have been examined by normalized ellipsometric parameter with respect to the chamber fill with N_2 Gas. Our results indicate linear behavior of resonance wavelength in ellipsometric parameter as a function of gas concentrations which can open the new insight for the sample's capability to hydrogen gas sensing applications.

[Scientists develop ultra fast method of changing fundamental property of light]



Researchers from the Reactive Plasmonics team at King's College London have developed a new method for rapidly changing the polarisation of light, one of its fundamental properties. The research, published in [Nature Photonics](), could lead to much faster data transfer and advance research into nano-materials.

A light wave undulates in different ways – known as its polarisation. The polarisation of light is changed by the material it passes through, so we can use it to learn about unseen nano-scale worlds such as drug chemistry and quantum electronics. Switching polarisation is also used to transfer digital information along fibre optic cables.

The electronic methods currently used to control the light polarisation in such applications is reaching its physical speed limit. Researchers at King's have overcome this problem, allowing polarisation to be switched at timescales of less than a millionth of a millionth of a second – hundreds of times faster than current electronic methods.

This will allow us to 'see' very fast nano-scale processes such as chemical reactions for the first time, by illuminating them with rapidly changing light. This helps us to understand the difference in formation of nasty chemicals and life-saving drugs, and allows us to study new materials that will bring about the next technological revolutions. This will also represent a major advance in data transfer speeds. By rapidly changing the polarisation of light – to represent a one or a zero – data can be passed along fibre optic cables and into your living room more rapidly. This will help meet growing data sharing demands driven by streaming and cloud services.

The team designed nano-structured materials that can control light polarisation using light itself – a technique known as 'all-optical polarisation control'. These nano-structures are known as metamaterials: materials with optical properties not available in nature. These thin, lightweight materials are constructed from elements smaller than a thousandth of a millimetre in order to create exotic optical effects.

In this case, the metamaterial is constructed of gold nano-particles. A high intensity light pulse is fired into the metamaterial, injecting energy into electrons in gold particles, which in turn changes the refractive index of the material.

A second pulse is fired at the metamaterial at the same time. As this pulse passes through the material, the change in refractive index changes its polarisation. This all happens instantaneously, allowing polarisation to be changed trillions of times per second. By simply shining two beams of light through the material, one beam is able to control the polarisation of the other at ultrafast speed.

The effect can be observed even with one beam. In this case, the polarisation of the light transmitted through the metamaterial changes with the intensity. It is like polaroid sunglasses which adjust themselves to remove glare whenever it is too much sunlight.

Luke Nicholls, the PhD student who carried out these experiments, said, “With everybody using more and more data, streaming videos, music and sharing pictures, we are fast approaching a point where the current internet infrastructure will not be able to cope. All-optical control provides an answer to this looming problem and hopefully sees an end to staring at the infuriating buffer wheel.”

This research also has potential beyond how many box sets we can download. Control of light at such short time scales could also feed into quantum information processing, where controlling the polarisation of light is integral for building successful quantum computing devices.

Reactive Plasmonic’s PI Anatoly Zayats of King’s College concludes: “This effect opens up many opportunities for new applications which can directly impact everyday life. The faster you can control light polarisation, the faster you can use light to transmit data and make measurements.”

more information:

- *Nature Photonics* **volume 11**, pages 628–633 (2017)
- doi:10.1038/s41566-017-0002-6

Unusual scaling laws for plasmonic nanolasers beyond the diffraction limit

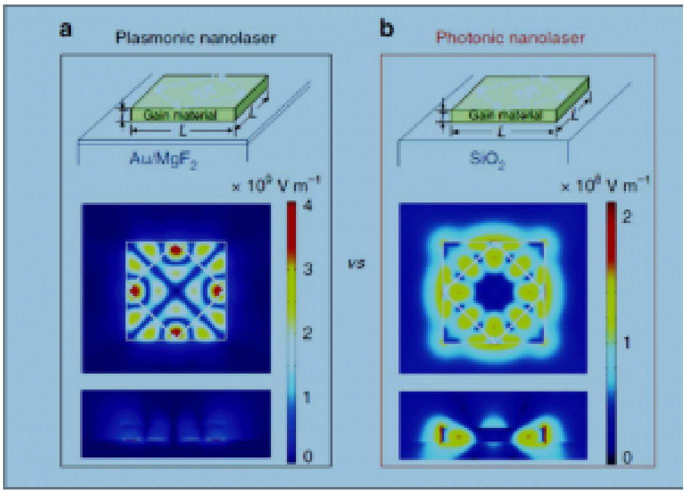


Fig. Schematic of plasmonic and photonic lasers and their cavity modes. a Top: schematic of the plasmonic nanolaser devices consisting of a nanosquare gain material on top of metal separated by a few nanometers of dielectric. Bottom: top and side views of electric field (|E|) profiles of a cavity mode in a 700 × 700 × 100 nm plasmonic cavity. b Top: schematic of the photonic nanolaser devices consisting of a nanosquare gain material on top of dielectric. Bottom: top and side views of electric field (|E|) profiles of a cavity mode in a 700 × 700 × 100 nm photonic cavity. In both panels, L and T are the length and thickness of the nanosquare, respectively, and TIR represents total internal reflection.

Plasmonic nanolasers are a new class of amplifiers that generate coherent light well below the diffraction barrier bringing fundamentally new capabilities to biochemical sensing, superresolution imaging, and on-chip optical communication. However, a debate about whether metals can enhance the performance of lasers has persisted due to the unavoidable fact that metallic absorption intrinsically scales with field confinement. Here, we report plasmonic nanolasers with extremely low thresholds on the order of 10 kW cm−2 at room temperature, which are comparable to those found in modern laser diodes. More importantly, we find unusual scaling laws allowing plasmonic lasers to be more compact and faster with lower threshold and power consumption than photonic lasers when the cavity size approaches or surpasses the diffraction limit. This clarifies the long-standing debate over the viability of metal confinement and feedback strategies in laser technology and identifies situations where plasmonic lasers can have clear practical advantage.

more information on: https://www.nature.com/articles/s41467-017-01662-6 ,

DOI: 10.1038/s41467-017-01662-6