NANOPHOTONICS

Black metals

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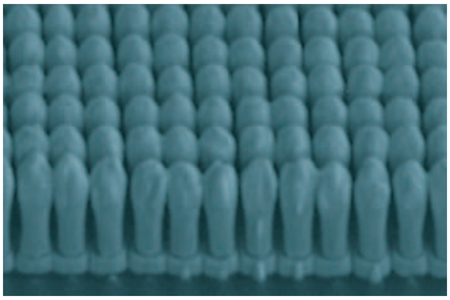

Mihail Bora and colleagues at Lawrence Livermore National Laboratory, USA, have investigated a metallic structure that absorbs more than 95% of incident light. Their work builds on other recent research that typically uses metallic grooves or 'funnels' to minimize the impedance mismatch or reflection with the surroundings with the aim of trapping or nanofocusing light in the sample. Using a square array of metal-coated nanowires, the team showed that absorbance of the substrates can be increased above 75% in the 400–800 nm range. The use of structures fabricated from wires with more pronounced matchstick-like tops formed more pronounced funnels, resulting in absorbances of over 90%. Nanowire arrays were patterned on 4-inch wafers by laser interference lithography and were transferred to a silicon substrate by directional deep reactive ion etching. The wire length and profile are determined by the etch time. Such structures that employ nanofocusing and dissipation to absorb light have been dubbed 'black metals'. *DP*

QUANTUM OPTICS

Gated photon transistor

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Photons are excellent carriers of quantum information, but it is difficult to induce the strong interactions between individual photons required for all-optical quantum information processing. Therefore, the realization of an optical transistor exhibiting gain with gate signals at the few-photon level remains a challenge. Now, Wenlan Chen and co-workers from USA, Austria and Japan have realized an optical transistor that is gated by a single stored photon. The system consists of an ensemble of laser-cooled ^{133}Cs atoms optically trapped in a high-finesse optical cavity. Each atom has a four-state N-type level structure with two stable ground states ($|g\rangle$ and $|s\rangle$) and two electronic excited states ($|d\rangle$ and $|e\rangle$). The group found that the control laser addressing the $|d\rangle \rightarrow |s\rangle$ transition produced electromagnetically induced transparency for gate photons addressing the $|g\rangle \rightarrow |d\rangle$ transition. By reducing the control laser power to zero, a weak gate photon pulse could be stored in the atomic ensemble. This pulse could later be retrieved by adiabatically reapplying the control beam. When the average number of stored gate photons reached 2.9, the transmission of the source light addressing the $|s\rangle \rightarrow |e\rangle$ transition was reduced by a factor of five. The available gain outside the cavity was 1.4, demonstrating a gain exceeding unity for transistor operation. *NH*

PLASMONICS

Graphene metamaterials

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Graphene-based metamaterials are promising for developing new approaches to efficiently control terahertz (THz) and infrared radiation. Two Japanese researchers, Atsushi Ishikawa (RIKEN) and Takuo Tanaka (Hokkaido University), have now experimentally and computationally investigated the THz plasmonic responses of structured graphene. Specifically, they analysed plasmon hybridization in a silicon oxide layer sandwiched between two graphene ribbons. The researchers produced this system by fabricating a single graphene ribbon on a thermally oxidized silicon oxide layer formed on a heavily doped p-type silicon substrate. The high reflectivity of the silicon substrate effectively generated a mirror image of the structure. This configuration greatly simplifies the experimental study of the plasmonic responses of complex hybridized systems. The researchers found qualitative agreement between experimental and numerical simulation results, demonstrating the important resonant behaviour of structured graphene and hybridized systems. They believe that this approach could be extended to more complex systems, making it promising for investigating and designing graphene-based THz and optoelectronic devices. *SP*

QUANTUM OPTICS

Single-photon detectors

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Superconducting single-photon detectors (SSPDs) are widely used as high-performance devices in many fields, including quantum information and quantum optics. The figure of merit of SSPDs is defined in terms of the dark count rate (DCR) as $\eta/(\text{DCR} \times \Delta t)$, where η is the detection efficiency and Δt is the timing jitter. The DCR is important because it governs the quantum bit error rate in quantum key distribution experiments. Now, Hiroyuki Shibata and colleagues from NTT Basic Research Laboratories, Japan, have demonstrated an SSPD composed of NbN that has an ultralow DCR of less than 1 cps. They found that the background signal at room temperature was produced by blackbody radiation propagating through the optical fibre to the SSPD. To reduce the DCR, they connected a coarse wavelength-division-multiplexer filter and a 1.6 μm rejection short-wavelength-pass filter in series to the SSPD and cooled the device to 0.38 K. On inserting the filters, at a bias current of 22 μA, the DCR of the system decreased from 14 cps to 0.1 cps, and the system detection efficiency decreased from 8.1% to 5.6%. As a consequence, the figure of merit increased by a factor of 97. Numerical calculations indicate that if the SSPD system is connected to a standard

ANGULAR MOMENTUM OF LIGHT

Photonic wheel

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Researchers at the University of Erlangen-Nuremberg, Germany have produced a novel light beam that possesses angular momentum whose axis is orthogonal to the direction of propagation. The optical state, which the researchers call a 'photonic wheel', is analogous to a bicycle wheel in motion along a path. The two types of angular momentum of light — spin momentum resulting from the light's polarization and orbital momentum produced by a twisted phase front — are usually longitudinal as their axes are parallel to the beam's motion. Peter Banzer and co-workers realize the 'photonic-wheel' state by converting a linearly polarized beam into two lateral components with opposing spin (one is left circularly polarized, whereas the other is right circularly polarized) using a special optical element consisting of two quarter waveplates. The beam is tightly focused using a microscope objective. Its electric field is then analysed by measuring the light scattered from a gold nanoparticle on a glass substrate that is scanned across the beam. The researchers propose that such a wheel state may find applications in various optical manipulation techniques, such as optical tweezers and spanners. *OG*