MICROWAVE PHOTONICS

Tunable down-converter

IEEE Photon. J. http://doi.org/cfxs (2017)

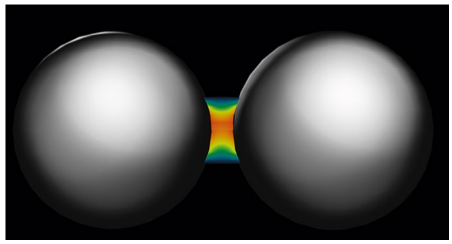
As carrier frequencies in microwave communication systems increase in order to enable higher rates of data transmission, detection and digitization of high-frequency signals with higher resolution and lower noise are required. Now, Yunxin Wang and co-workers from China have developed an all-optical microwave photonic frequency down-converter that offers tunable, continuous phase control between 0° and 360°. The system consists of a laser source, a dual-parallel Mach–Zehnder modulator (DPMZM), an optical bandpass filter (OBPF) and a photodetector (PD). The laser provides the optical carrier, and the radio-frequency (RF) and local oscillator (LO) signals are fed to the top and bottom sub-Mach–Zehnder modulators (MZMs), respectively. The two sub-MZMs are both biased at the minimum transmission point to implement the carrier-suppressed double-sideband modulation. The RF and LO sidebands are obtained by the OBPF and sent to a PD to produce an intermediate frequency (IF) signal. In this way, an RF signal can be down-converted to a phase-tunable IF signal. The phase of the IF signal can be linearly shifted from 0° to 360° by adjusting the bias voltage of the parent MZM in the DPMZM. The measured spurious-free dynamic range can reach values as high as 100.2 dB $Hz^{2/3}$. The phase deviation and power ripple of the IF signal are less than 2° and 0.26 dB, respectively. *NH*

https://doi.org/10.1038/s41566-017-0063-6

PLASMONICS

Landau limit

ACS Photon. http://doi.org/cfxt (2017)



Credit: American Chemical Society

The strong enhancement of electromagnetic fields in small dielectric gaps between metal structures is one of the main attractive characteristics of plasmonics. However, limitations on the size of the enhancement arise due to fabrication capabilities and heat-related damage. Another phenomenon, Landau damping, is usually neglected as a limitation because it is assumed to be weak unless structural features are on the subnanometre scale. Now, Jacob Khurgin and colleagues from the USA and Taiwan, have theoretically considered the case of a metal dimer — two closely spaced metal particles with a dielectric gap — and found that the effect of Landau damping on field enhancement and distribution may be relevant for gaps as large as 2 nm or more, which is a feature size already achieved in experimental situations. For slightly smaller gaps, the effect may be drastic. For example, a dimer formed by two 2.5 nm gold particles spaced by a 0.5 nm gap yields a calculated surface damping rate (resulting from non-local modifications) that is two orders of magnitude larger than for bulk gold. This increased dissipation in turn reduces the maximum electromagnetic field enhancement by a similar order. The authors conclude that Landau damping actually may be the most practically relevant limit to plasmonic enhancement of electromagnetic fields. *DFPP*

https://doi.org/10.1038/s41566-017-0064-5

QUANTUM DOTS

Reduced threshold

Nat. Nanotech. http://doi.org/cfxr (2017)

The threshold for optical gain in colloidal semiconductor quantum dots (QDs) can be dramatically reduced by the use of interface engineering and charge doping. Kaifeng Wu and co-workers from Los Alamos National Laboratory in New Mexico, USA fabricated QDs consisting of a core of CdSe, an alloy of $CdSe_xS_{1-x}$ and a shell of CdS. The QDs have an energy bandgap of ~1.9 eV (which corresponds to a red emission wavelength of 650 nm) and extra electrons are introduced through the use of a photochemical reduction, where a hole from the QD is transferred to lithium triethylborohydride ($LiEt_3BH$) that acts a 'hole scavenger'. The degree of charge doping can be controlled by the amount of $LiEt_3BH$ used. Heavily charged QDs with ~6 electrons were found to have dramatically reduced optical gain thresholds that were about 50 times smaller than neutral QDs. The researchers say that the approach indicates the viability for zero-threshold optical gain. Analysis also shows the laser threshold of optically excited, doubly charged QDs is around 0.5 kW cm^{-2}, which is more than one order of magnitude smaller than neutral or singly charged QDs and potentially compatible with the use of commercial LEDs as a pump source. *OG*

https://doi.org/10.1038/s41566-017-0062-7

MICROSCOPY

Accuracy boost

Phys. Rev. X **7**, 041007 (2017)

Although microscope technology has progressed steadily, the ability to extract quantitative information from microscopy images has lagged behind. Matthew Bierbaum and colleagues from Cornell University, USA, now report a generic, methodological approach to extract all the useful information theoretically contained in a complex microscope image. The method, called parameter extraction from reconstructing images (PERI), creates an optical model of a microscope based on the physics of the light interacting with the sample and with the microscope's optical train. In the process, the fluorescent dye is distributed unevenly throughout the sample, the dyed sample is illuminated unevenly by the laser, and the resultant image is noisy and blurred due to diffraction. Least-squares fitting is then carried out for every parameter in the model to find the correct particle positions, particle radii, illumination field and point-spread function. It takes between 1 and 24 hours for a large confocal image to be analysed, depending on previous knowledge of the microscope's global parameters. The team demonstrates this approach with a confocal image of colloidal spheres and report measurements of particle positions and radii to within 3 nm accuracy, a 10–100 times improvement over existing methods. The open-source code is available online for researchers to analyse their existing images. *RW*

https://doi.org/10.1038/s41566-017-0065-4

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