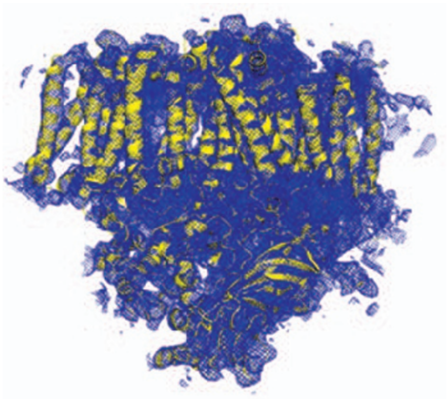
PHOTOSYNTHESIS

X-ray investigation

Science http://dx.doi.org/10.1126/science.1234273 (2013)



© AAAS 2013

X-ray diffraction, the materials analysis technique used to reveal the structure of DNA in the 1950s, is receiving renewed interest, especially for protein crystallography. One reason for this is the advent of free-electron lasers, which can provide short, intense X-ray pulses. Although X-ray diffraction is useful for determining structural information, other techniques such as nonresonant X-ray emission spectroscopy, which probes electron levels, can provide additional information about a sample. Now, Jan Kern and colleagues from the USA, Germany, Sweden and France have used sub-50-fs X-ray pulses produced at the Linac Coherent Light Source at Stanford, USA, to conduct simultaneous X-ray diffraction and X-ray emission spectroscopy measurements of microcrystals of photosystem II at room temperature. Photosystem II is a metalloenzyme that plays a critical role in photosynthesis; it is found in green plants, algae and cyanobacteria. The researchers report that the photosystem II crystals remained intact during measurements and hope that the technique can be used for time-resolved studies of light-driven structural changes. *DP*

METAMATERIALS

Ultrasound detector

Adv. Mater. http://dx.doi.org/10.1002/adma.201300314 (2013)

Piezoelectric sensors for detecting acoustic signals (including ultrasound) are useful but limited by their minimum detectable acoustic pressure and poor sensitivity at high frequencies. In contrast, optical sensors for ultrasound signals provide good sensitivity over a broad bandwidth. Now, Vladislav Yakovlev and colleagues from the USA and the UK suggest using metamaterials for acoustic detection. They propose detecting acoustic waves by exploiting the high sensitivity of plasmonic nanorod metamaterials to variations in the refractive index of the surroundings. A pressure-induced variation in the refractive index of a polymer adjacent to the nanorods imparts a frequency shift to a propagating light beam, thus allowing the ultrasound signal to be detected optically. The team also investigated photoacoustic wave generation and detection. Their prototype devices had a measured detection limit of about 500 Pa, but theoretical calculations suggest that an optimized metamaterial sensor might have a sensitivity of a few tens of Pascals, and could possibly outperform sensors based on surface plasmon resonance. The team emphasizes that the nonresonant nature, good linearity, high bandwidth and subnanosecond response time of metamaterial-based sensors make them promising for biomedical applications. *DP*

PHOTONIC CRYSTALS

Nanoimprinted lasers

Appl. Phys. Lett. **102,** 073101 (2013)

Research into dye-doped polymer lasers is popular because of the ease with which dyes can be incorporated into polymers and the broad range of emission wavelengths that can be obtained by using different dyes. Vincent Reboud and co-workers from Spain, France, Poland and Ireland now report how single-step nanoimprint lithography can be used to fabricate polymer lasers on two-dimensional photonic-crystal slabs. They believe this approach will be more cost-effective than existing fabrication techniques because of its ability to pattern large volumes of polymer with a high resolution in a single step. The team used their process to make nanoimprinted triangular-lattice photonic crystals in a dye-chromophore-loaded printable polymer. Using optical pumping with a 532-nm frequency-doubled *Q*-switched Nd:VO_4 laser emitting 1-ns pulses at 10 Hz, the team observed lasing at the photonic bandedge at thresholds as low as 3 μJ mm^{-2}. The lasing threshold was found to depend on the dye concentration and the lattice constant of the photonic crystals. The findings demonstrate the suitability of nanoimprint lithography to produce cost-effective optically pumped lasers. The researchers suggest that the laser lifetime could be increased by replacing the dye molecules with optically active semiconductor nanocrystals. *RW*

QUANTUM OPTICS

Entangled spins

Nature Phys. **9,** 139–143 (2013)

Diamond defect spins are particularly interesting as a potential route for realizing a solid-state spin qubit system that operates at room temperature. However, entangled electron spins have yet to be demonstrated because of the large interaction of each electron spin with residual paramagnetic impurities or nuclear spin moments in the diamond lattice. Now, Florian Dolde and co-workers in Germany have experimentally demonstrated entanglement between two coupled electron spins formed by nitrogen–vacancy defects in diamond. The researchers created nitrogen–vacancy defects by implanting nitrogen ions ($^{15}N^+$) with kinetic energies of 1 MeV in diamond. The magnetic dipole coupling between the defects was sufficiently strong at a distance of 25 nm that the spins tended to align when excited by microwaves. Two-photon

QUANTUM OPTICS

Reversible storage

J. Opt. Soc. B **30,** 687–690 (2013)

Reversible storage of entanglement is one of the basic requirements for realizing quantum repeaters. Tianhui Qiu and colleagues from Beijing Normal University and Jiangxi Normal University in China have now theoretically investigated the feasibility of using electromagnetically induced transparency in a thermal atomic ensemble to store and retrieve photon entanglement. The entangled photon storage model under consideration consists of two identical but spatially separated photon storage systems. Each system has a Λ-type atom–field interaction configuration. An 'ensemble' here consists of *N* identical but independent thermal atoms distributed homogeneously in one-dimensional space. The researchers considered a storage process in which the entangled photonic state to be stored contains only a single photon shared by two modes. A numerical simulation involving the Doppler shift of the signal field indicated an excellent ability to retrieve entangled states within the atomic ensemble, even in the presence of atomic thermal motion. *NH*