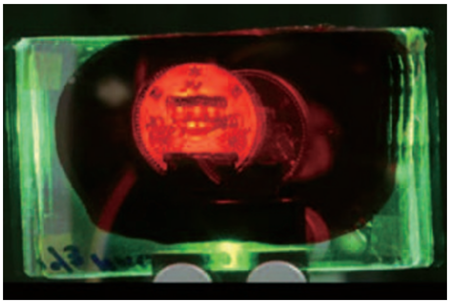
HOLOGRAMS

Fast response

Opt. Mater. Express **2,** 1003–1010 (2012)



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The realization of holographic displays that are able to generate three-dimensional images with a video-rate refresh speed is a long-sought-after goal of photonics researchers. However, so far the low response speed of holographic materials has largely limited applications to the display of static images. Now Naoto Tsutsumi and co-workers from Kyoto Institute of Technology and Chitose Institute of Science and Technology in Japan have demonstrated that a holographic medium made from the polymer poly(methyl methacrylate) doped with an organic compound called NACzE is capable of recording and displaying new images within just a few seconds. A further benefit is that an electric field does not need to be applied to the medium to enable viewing of the images. The display's large area and thin geometry — it consists of a 50-μm-thick film sandwiched between two glass plates measuring 7.5 cm by 5 cm — means that in future it could be suitable for large signage applications. Although the temporal response of the display is not yet fast enough for video requirements, the authors say that it could be improved by adjusting the glass transition temperature of the polymer film. *OG*

SILICON PHOTONICS

Under pressure

Nano Lett. **12,** 4200–4205 (2012)

The origin of photoluminescence from silicon nanocrystals has been a controversial topic for many years. In an attempt to gain a better understanding of the mechanisms involved, Daniel Hannah and coworkers in the United States have now performed a series of experiments to investigate the part that pressure plays. Samples of alkane-terminated, plasma-synthesized silicon nanocrystals (2.6 or 4.6 nm in diameter) were placed into a diamond anvil cell and both X-ray diffraction and photoluminescence data were collected as functions of pressure up to 73 GPa. The data suggest that the bright emission from the nanocrystals originates from an $X_{\mathrm{conduction}}$-to-$\Gamma_{\mathrm{valence}}$ transition associated with silicon's bulk properties rather than from defects, as has been postulated previously. The researchers also comment that the transition remains highly indirect despite quantum confinement effects. *OG*

LASER COOLING

Beyond the recoil limit

Science **337,** 75–78 (2012)

Laser cooling can reduce atoms to a temperature lower than that achievable by any other known process, leading to fundamental insights in many fields. Now Matthias Wolke and researchers from the University of Hamburg, Germany, have demonstrated a cavity-based laser cooling scheme that makes it possible to prepare Bose–Einstein condensates with particle densities and temperatures inaccessible with conventional laser cooling. An optical cavity used for cooling can be characterized by two important figures: the Purcell factor (the rate at which free-space modes will scatter into a cavity mode) and the spectral width of the transmission resonances. The researchers operate their atom–cavity system in a previously unexplored quantum regime where the Purcell factor is greater than one (as high as 43) and the frequency shift associated with the scattering of a single photon exceeds the bandwidth of the cavity. Temperature control of the atoms is demonstrated on a subrecoil energy scale at densities of the order of 10^{14} cm^{-3}. The authors predict that their scheme could cool a warmer-than-usual sample of atoms to the point at which quantum degeneracy occurs. *SA*

MAGNETO-OPTICS

Quantifying magnetic light

Nature Commun. **3,** 979 (2012)

Magnetic dipole transitions at optical frequencies are such rare events that they are often considered to be forbidden transitions. Now Tim Taminiau and colleagues from the United States, Spain and the Netherlands have quantified the magnetic nature of light emission by using energy- and momentum-resolved spectroscopy of the rare-earth ion trivalent europium (Eu^{3+}). The researchers prepared thin films of europium-doped yttrium oxide (Eu^{3+}:Y_2O_3) and engineered interference effects to distinguish between the light emission resulting from electric dipoles and magnetic dipoles. Emissions from electric and magnetic dipoles differ in symmetry and polarization. An experiment was designed in which constructive interference would occur between emitted and scattered light for an electric dipole, as the electric field is symmetric with respect to the dipole axis, and, conversely, destructive interference would occur for a magnetic dipole. To analyse the emissions quantitatively, rate equations were used to model the transitions. A transition at 592 nm was found to be predominantly magnetic (90.8 $\pm$ 2%) and a transition at 612 nm was found to be electric (99 $\pm$ 1%). *SA*

ADAPTIVE OPTICS

Single-photon metrology

Phys. Rev. Lett. **109,** 053602 (2012)

A pulse of light can contain many different quantum states that take on arbitrarily complex shapes in space and time. Constantina Polycarpou and co-workers from Italy, Germany and Brazil have now demonstrated an adaptive technique for measuring ultrashort single-photon pulses with little or no prior information about the shape of the light. In their scheme, measurement of a quantum state of light is achieved when the spatial, temporal and spectral properties of the light are completely matched to that of a reference beam, termed the local oscillator. Perfect overlap of these properties means perfect detection, and the degree of overlap is used as the optimization parameter in a genetic algorithm that mimics biological evolution. The local oscillator is shaped by two spatial light modulators that alter the overlap, and an adaptive correction is sent accordingly to the modulators to ensure that they converge to an optimal shape. The researchers verified their technique by creating complex single-photon pulse shapes and measuring the optimized detection efficiency. The most challenging state created was a single photon in a coherent superposition of two states that are separated in frequency space. The optimized detection efficiency was about 45%. Although only the frequency components were manipulated here, the authors say that their technique may be effectively applied to measure any quantum state, including bright multi-photon states, as long as a suitable optimization parameter is available. *SA*

OPTICAL COMMUNICATION

All-optical storage

Opt. Express **20,** 18224–18229 (2012)

A major challenge in optical communication systems is the all-optical synchronization of