much longer timescale than the controlled evolution of the hole-spin system. On the other hand, the first frequency-domain measurements of spin coherence by the Warburton group[8], which found particularly long values of T_2^*, involved optimized p-doping with carbon instead of beryllium, as used in the coupled-dot samples of Greilich *et al.* Although great care should be taken when comparing the magnitudes of T_2^* values obtained using different techniques, it is known that p-doping with carbon is more stable than with beryllium, as the electrical noise introduced by the broadened doping profiles of mobile beryllium atoms can be too high for such sensitive measurements. Further optimization of the sample crystal growth process may lead to significant improvements in T_2^*. Similar improvements could be achieved by reducing the sensitivity to voltages of the g factor or exchange interaction in coupled SAQDs.

It will be interesting to see if the coherence limit determined by the hole–nuclei interaction can be experimentally reached in the near future. Improvements in coherence time may make it possible to apply other hole-spin control techniques such as electric dipole spin resonance[9] to allow the on-chip electrical control of spin. Electrical control, although intrinsically slower than optical techniques, is appealing because of its scalability and suitability for chip-level integration. These latest findings, alongside other research investigating the potential of holes as qubits, all indicate a significant growth of interest in this area[10,11].

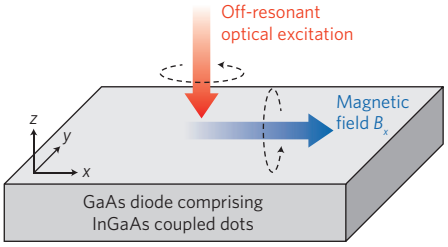

Figure 2 | Experimental set-up and control scheme. External magnetic field is applied in the plane of the sample along the x-axis, which induces spin rotations in the y–z plane. Off-resonant pulsed optical pumping with circularly polarized light in the z-direction produces an effective magnetic field along the z-axis, together with corresponding spin rotations in the x–y plane.

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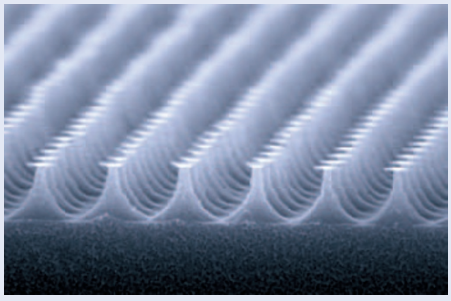
OPTICAL LITHOGRAPHY

Azopolymer option

Making lithographic masks from azobenzene-containing polymers (azopolymers) rather than conventional photoresist provides a convenient and fast means of performing optical interference lithography. That's the view of researchers from Aalto University in Finland and Tokyo Institute of Technology in Japan, who have now used this technique to fabricate large areas of silicon nanostructures (*Adv. Mater.* **23,** 4174–4177; 2011).

Azopolymer films are attractive because the efficient polarization reversibility of azobenzene makes it easy to create photo-induced surface patterns. Unlike traditional photoresist, which is sensitive to the intensity of short-wavelength visible light, mask formation in azopolymers is driven by polarization modulation within the incident interference pattern, and is therefore insensitive to stray light. Moreover, because azopolymers are sensitive to a wider wavelength band of light and exhibit better tolerance to overexposure than traditional photoresist, complex surface patterns can be created by applying multiple interference patterns.

The fabrication procedure developed by Andriy Shevchenko and co-workers involves spin-coating a thin film of azopolymer onto the top of a silicon substrate. Illuminating



the surface with an optical interference pattern generates a surface-relief grating in the film. The next step is to partially etch the polymer by reactive-ion etching and then dry-etch the silicon substrate in regions that do not contain the polymer mask. The final step is to strip away the remaining mask, leaving only the desired silicon pattern. Unfortunately, because the azopolymer mask is soft, etches in the silicon are slightly angled rather than perfectly rectangular, which limits the achievable etching depth of the technique.

To overcome this problem, the researchers adopted an advanced fabrication approach that adds a 20 nm layer of amorphous silicon and a 5-nm-thick alumina layer beneath the azopolymer film. Alumina is more resistant than azopolymer to reactive-ion etching and thus functions as a hard mask with steep side walls. The amorphous silicon provides good adhesion to the azopolymer film. The amorphous silicon layer is etched through the soft mask using reactive-ion etching followed by wet etching of the alumina layer, after which the silicon is dry-etched and the mask is stripped off.

Using this advanced approach, the researchers were able to fabricate high-quality one-dimensional periodic surface structures in silicon with feature sizes of the order of 100 nm over an area of around 1 cm^2. Two-dimensional silicon patterns can be obtained by exposing the same interference pattern twice and rotating the sample by 90° between exposures. Changing the exposure and etching parameters provides control over the geometry of the etched structures.

The use of azopolymers relaxes the environmental requirements of optical lithography, allowing it to function at longer wavelengths and under room lighting. The nanostructures fabricated in this work could be useful in a variety of fields, including surface-enhanced fluorescence, Raman scattering spectroscopy and photonic-integrated circuits.

RACHEL WON