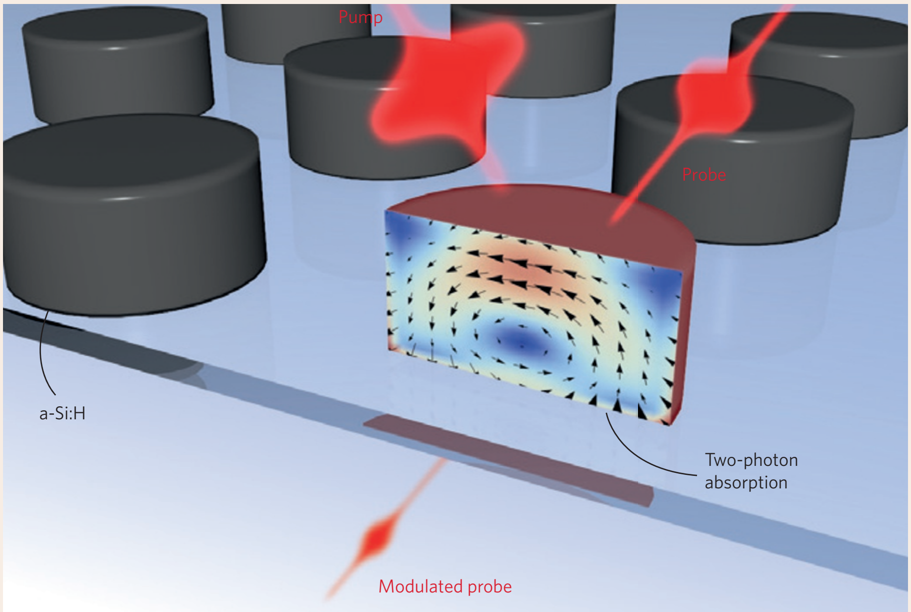
DIELECTRIC NANOSTRUCTURES

Ultrafast responses

Dielectric resonators with high refractive index (>2) have recently emerged as alternatives to metallic structures, constituting promising tools for manipulating the light–matter interaction. Compared with metallic resonators, their losses are significantly lower and they exhibit not only an electric but also a magnetic Mie mode. Furthermore, they are compatible with silicon-based technologies. Recently, such structures have been used to realize ultrafast all-optical switches, which are essential components in compact, high-speed optical communications networks. All-optical switches require strong optical nonlinearities, and ideally low losses. Now, Yuri Kivshar and co-workers (*ACS Nano* http://doi.org/752; 2015) have demonstrated that both conditions can be met with dielectric resonators, with their magnetic Mie modes being key.

The team studied how femtosecond laser pulses centred at 750 nm are self-modulated when passing through hydrogenated amorphous silicon nanodisks (a-SiH; image). Nanodisks with radii in the range 105–140 nm exhibited magnetic resonances in the vicinity of the frequency of the laser used in the experiment. With pump energies as low as picojoules per nanodisk, transmission was shown to decrease by up to 60%, as a result of the overlap between the laser and the magnetic mode.

Photon-induced nonlinearities are usually linked to two-photon absorption and free-carrier effects, with femto- and picosecond characteristic times, respectively. As such, effects related to free carriers would induce slower switching times and should therefore be excluded. The authors managed to eliminate this contribution completely by precisely tuning the laser pulse towards the right slope of the magnetic resonance.



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The researchers performed pump–probe experiments (see image) to clarify the dynamics behind their observations and to establish the speed of switching in their system. They used 45-fs pulses for both pump and probe, with the latter arriving on the sample after an adjustable time delay. By mapping the transmittance as a function of the time delay between the probe and pump pulses, they obtained switching times as low as 65 fs. This marks an approximately twofold reduction of the 115 fs reported for split-ring resonator metamaterials (*Adv. Mater.* **23,** 5540–5544; 2011).

The demonstration of low-power, ultrafast switching using silicon nanodisks underlines not only the potential of the magnetic component of these structures, but also constitutes an important step towards merging all-optical switching with existing technologies.

MARIA MARAGKOU