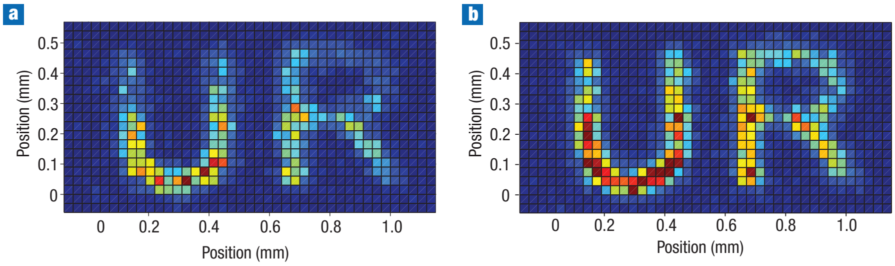

Figure 2 Successful delay of whole images, even at low light levels. Delayed, **a**, and non-delayed, **b**, versions of an image of the letters 'UR' (for University of Rochester), made from light beams that contain on average 0.8 photons. The delayed light faithfully reproduces the image, offering comparable resolution to the non-delayed image. Both images are false colour representations. Figure reproduced with permission from ref.10. Copyright (2007) APS.

quantum-mechanical in nature, for example, in a single-photon state.

An attractive feature of this set-up is that it does not require another laser beam to induce delays, in contrast to slow-light schemes based on EIT or stimulated scattering. Nevertheless, there are certain applications (such as image correlation) in which relatively fast tuning of the image delay would be desirable, in which case a second laser beam could be introduced as a control. By tuning this control beam close to one of the atomic-absorption resonances and saturating its laser transition, the dispersion and group delay of the image beam could be successfully controlled. Another important next step would be to store the image for an appreciable time and then release it, as has been achieved with single pulses[5–7].

The past few years have witnessed a remarkable variety of techniques for buffering light pulses, including some that can support signal bandwidths that could be useful for applications such as telecommunications. However, the next challenge will be to try to implement these slow-light techniques in functional devices so that the full potential of optical buffering can be realized. On a similar note, the next step for whole-image buffering will be to come up with a really useful platform: one that does not rely on a hot or cold atomic vapour, but instead involves a compact, robust solid-state material that can be readily integrated into future imaging systems.

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VIEW FROM…NANOMETA-2007

Big minds think small

Optical technology is becoming smaller and smaller, and it doesn't get much smaller than nanophotonic devices and metamaterials. NANOMETA-2007 gave researchers the opportunity to gather together in the cold to discuss these hot topics.

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High in the Austrian Alps, 260 scientists from across the globe assembled in early January to discuss some of the most exciting topics in photonics. NANOMETA-2007 was the First European Topical Meeting on Nanophotonics and Metamaterials, organized by the European Physical Society. Held at the Tyrolean ski resort of Seefeld, the conference aimed to bring together researchers from a wide range of backgrounds. "The reason for that is very simple: many of the ideas from metamaterials came from the microwave community, but the real applications are likely to be in photonics," explained Nikolay Zheludev from the University of Southampton in the UK, co-chair of the conference along with Ekmel Ozbay from Bilkent University in Turkey. "So as optics researchers move into metamaterials, they want to be exposed to the ideas of the microwave community, while the microwave scientists want to see their ideas find new applications."

Metamaterials are man-made materials with a nanoscale structure. Because their features are smaller than the wavelength of light, photons passing through metamaterials effectively 'see' a single, continuous medium. Through careful design, the material's electromagnetic properties can be artificially engineered. One such property that scientists are keen to explore is a negative refractive index. Natalia Litchinitser from the University of Michigan is one of a growing number of scientists investigating the nonlinear properties of negative-index materials[1]. A simple way to introduce optical nonlinearity to a negative-index material is to bring it into contact with a nonlinear positive-index medium. Such structures are highly sensitive to the properties of the metamaterial, providing a useful characterization technique.

One aspect of metamaterials that has made headlines during the past 12 months is cloaking, and it continues to capture the imagination of the metamaterials community. In May 2006, Ulf Leonhardt[2] at the University of St. Andrews and John Pendry[3] at Imperial College London, both reporting in *Science*, described how metamaterials can be used to bend light at will, even directing it around an object so that it becomes invisible to an outside observer. With cloaking already demonstrated at microwave frequencies, such technology may not be as fanciful as it may seem. As Zheludev puts it, "It is not just Harry Potter stuff," referring to the angle taken by many newspapers when the original results were published. Speaking at the conference, Leonhardt gave a global perspective of the cloaking idea and took the concept further by drawing parallels to phenomena common in general relativity, such as black holes[4], describing how this analogy could help to design better metamaterial-based devices.

As the name suggests, nanophotonics is all about getting light into very tiny volumes. The spin-off technology could allow magnetic disks to store higher densities of data or could improve the resolution of imaging systems to beyond the diffraction limit of light. One of Zheludev's many personal highlights of the conference was the work of Vahid Sandoghdar's group at ETH Zurich. By concentrating laser light into a small enough area, the team has shown that even a single atom can have a measurable effect on the transmitted light intensity, opening the door to realistic single-atom spectroscopy[5]. Although work similar to this has been done on very small particles in the past, Zheludev points out, "It is one thing dealing with nanoparticles that have a million atoms, and something totally different to show this on one atom."

As is to be expected in a rapidly developing field of science, there are one or two contentious issues. At present, metamaterials at optical wavelengths are severely limited by loss. It is the view of some members of the community that it may never be possible to compensate for these losses, as any attempt to do so would destroy the negative index. So where does this leave the metamaterials field? Zheludev, who remains undecided in the argument, believes that the majority of researchers with an optimistic view on these losses provide powerful counter-arguments. Either way, there is much more to this topic than just negative refraction and superlenses. He feels metamaterials still offer a wide range of properties that cannot be obtained from natural materials: optical elements that operate independently of incidence angle, tailored spectral filters and beam splitters, to name but a few. "What I am trying to say is that even if progress in the development of nanolenses becomes slow or halts altogether for optical purposes, there is still an enormous range of applications for metamaterials — I truly believe in that."

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DISPLAYS

A turning point for electronic paper?

A Cambridge start-up company is opening a large manufacturing facility for organic electronic circuits. The news is expected to accelerate the deployment of electronic-paper displays.

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After nearly 40 years of using photolithography to make microchips, the electronics industry could be in for a bit of a shake up as one factory in Germany prepares to break the mould.

Plastic Logic, a UK spin off from Cambridge University, has received $100 million (£50.5 million) in venture capital funding to build the world's first commercial organic-electronics factory in Dresden. Instead of working with photomasks, metals, silicon and traditional etching technologies, this facility will create thin and flexible plastic electronic circuits using organic semiconductors and printing techniques more commonly found in graphic houses.

Although conducting polymers have been used to make circuits before, this will be the first facility to print them commercially and on such a scale. "It's going to be a volume-manufacturing facility, it's not a prototype or demonstrator line," says Henning Sirringhaus, a Cambridge physicist and co-founder of Plastic Logic.

PLASTIC LOGIC

Figure 1 Welcome boost. Organic electronics is ideal for powering thin and flexible displays.

The first product to roll off this factory floor will be the drive electronics needed for active-matrix 'electronic-paper' displays at the heart of a new type of portable reading device, according to Sirringhaus. For the time being the company is not giving much away about the precise details of this device. But given the company's partnership with the MIT spin off, E-Ink, it seems probable that it will mark a big step forward in the deployment of electrophoretic displays — a form of electronic paper that