Light at the end of the waveguide


GETTY

In optoelectronics, one of the intentions is to integrate electronic as well as optical components on a single chip. To guide light beams across such an integrated circuit requires optical structures that can connect the two components. However, it has proved difficult to find interconnects of a suitable size for connecting the small electronic components with the larger optical devices. A concept for highly confined light transport is now demonstrated by Dionne, Lezec and Atwater *(Nano Lett.* doi:10.1021/nl0610477; 2006), who fabricated waveguides composed of a dielectric core surrounded by a metallic cladding. The core is as thin as 50 nm — much smaller than those in competing techniques such as photonic crystals and only about a fifth of the wavelength of light used in the experiments. The key to enabling this reduction in size lies in the use of surface plasmons — collective excitations of electrons at the interface of the core and the metallic cladding. Although the propagation distance achieved so far is only of the order of a few micrometres, it should be easily scaleable to at least a few tens of micrometres.

NANOSCALE RESONATORS IN LIQUID

Mechanical resonators are used in a number of sensing applications, but when smaller operating devices are required in the type of viscous environment most relevant to biological systems, losses resulting from viscous drag arise. Indeed, this problem of viscous damping has prevented nanoscale flexural resonators from operating in a liquid environment. Harold Craighead and colleagues demonstrate the operation of radio-frequency nanoscale resonators in air as well as liquids such as water, alcohol and buffer solutions (*Nano Lett.* doi:10.1021/nl061397t; 2006). Bilayered beam-type devices (with cross-sectional dimension of the order of 100 nm) made of gold/chromium on silicon nitride are driven into resonance by modulating the amplitude of a focused blue laser, leading to a differential expansion of the materials and a harmonic flexural displacement. This laser drive technique can impart sufficient energy to overcome the strong viscous damping present in these media, resulting in a mechanical resonance that can be measured by optical interference techniques. This approach greatly extends the viscosity range over which such sensitive devices can be operated, and provides insight into our understanding of the interaction of such small mechanical devices with their environments.

DNA at the crossroad

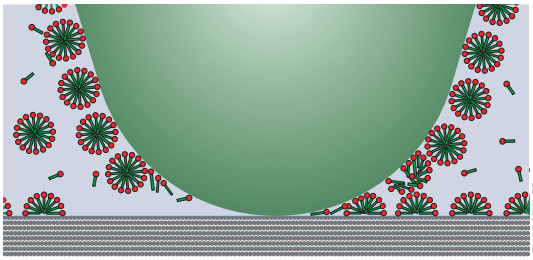
A two-dimensional, asymmetric lattice of nanochannels crossed at 90° and patterned by electron beam lithography on a fused silica wafer, made by Robert Riehn and colleagues, appears to be picky with respect to DNA strands (*Nano Lett.* doi:10.1021/nl061137b; 2006). As expected, the nanochannels stretch the DNA molecule to let it through when a direct current is applied at a 45° angle to the principal directions of the lattice. But the peculiar thing about this lattice, brought about by the asymmetry in channel dimensions, is that DNA strands will move only with a specific orientation. This behaviour is understandable as a confinement effect: the strands much prefer to travel in the wider channels. More curiously, when an alternate current is applied the strand will change its orientation by 90° and travel only in the narrower channels. The authors explain this comes from an interplay of entropic and dielectrophoretic energy contributions close to the nanochannel junctions. The ability to tune these contributions at asymmetric junctions will enable targeted point-like DNA modification, switches between nanofluidic stages, molecule sorters and the like.

Transistors at the interface

Very-high-mobility electron gases can form at the interface between two perovskite-oxide insulators. This recent surprising discovery has triggered a considerable amount of research, fuelled in part by the ultimate goal of oxide-based electronics devices with performances comparable to or higher than present semiconductor ones. Much effort has focused on learning how to tune the carrier mobility by varying either the thickness of the insulators, or the growth conditions. Stefan Thiel and colleagues in Augsburg have now demonstrated the possibility of using an external electric field to tune the carrier density and mobility of the two-dimensional electron gas that forms at the interface between a layer of $LaAlO_3$ and a layer of $SrTiO_3$ (*Science* doi:10.1126/science.1131091). Based on previous studies, they chose a structure with a thickness of $LaAlO_3$ such that the interface was insulating. By applying a gate voltage across the structure, they observed a transition to the metallic state, with the conductance varying over seven orders of magnitude. There is certainly large room for improvement, but these results directly demonstrate the possibility of using perovskite-oxide interfaces as building blocks for more complex oxide electronics circuits.

Speedy self-healing

Surfactants on a surface self-assemble into highly ordered coatings, which have potential for corrosion inhibition and lubrication. One of the most appealing characteristics of these so-called micellar coatings is their ability to self-heal, but the timescale at which this occurs is difficult to assess with conventional imaging techniques. Schniepp *et al.* have adapted traditional atomic force microscopy (AFM) to address this issue (*J. Am. Chem. Soc.* doi:10.1021/ja0624826; 2006). In contrast to conventional AFM, where the imaging tip is held above the surfactant layer, Schniepp *et al.* push the tip onto the graphite substrate, thereby piercing the micellar coating. In this regime, surprisingly both the substrate and the hemicylindrical surface micelles are visible, as the substrate is imaged by the end of the tip and the coating micelles by the sides. The coating is disrupted each time the tip scans the image area, but as its image appears complete, it must reform before the tip next passes over the same area. The authors can therefore infer the self-healing timescale from the tip scan rate — for the surfactant sodium dodecyl sulphate on graphite, they find it to be less than 6 ms.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