INTEGRATED PHOTONICS

Strain stretches photons

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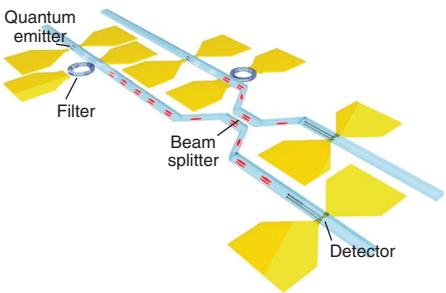

Credit: American Chemical Society

Many quantum optics applications require integrated photonic circuits that generate, process and detect single photons with high control: hence the desire for deterministic, non-intrusive manipulation of the optical properties of components such as single-photon emitters, beam splitters or couplers. Elshaari et al. now combine bottom-up and top-down techniques to develop a single-photon source and frequency filter on the same platform, both with voltage-controlled frequency tuning.

A piezoelectric substrate sandwiched between two electrodes controls the emission frequency of a single-photon emitter and the pass frequency of a ring resonator by means of strain. They pattern a SiN waveguide on a piezoelectric substrate and place an InAsP/InP nanowire quantum dot at its end by nanomanipulation. A potential difference applied to the piezoelectric layer then stretches the nanowire. The emission frequency shifts linearly and reversibly with the applied voltage and shows frequency stability over hours. Elshaari et al. also pattern a ring resonator on the same type of substrate, which can be used as a pass filter. Strain applied by the piezoelectric substrate changes its transmission frequency, again linearly with voltage. Their approach avoids wire bonding but uses direct patterning onto the piezoelectric substrate, which increases the wavelength stability and precision of the device. *BH*

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MOLECULAR MOTORS

Light does it all

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Light-driven molecular motors, such as the Feringa motor, generally work through a combination of light-induced and thermally induced steps. Now, Gerwien et al. have demonstrated a different light-driven unidirectional molecular motor in which all the steps are driven by light.

The researchers use a hemithioindigo chromophore that bears a sulfoxide stereocentre attached to a chiral axis formed by a sterically crowded styrene fragment. As a result, it can exist as four different diastereoisomers, all of which are thermodynamically stable at room temperature. The photochemical steps consist in a single-bond rotation, a double-bond isomerization and a hula-twist motion (a concerted double-bond isomerization and an adjacent single-bond twist by 180°). In total, it takes three steps for the molecule to return to the initial configuration. Gerwien et al. demonstrate that their hemithioindigo can indeed undergo unidirectional motion under steady-state irradiation at 442 nm. At room temperature, about 80% of molecules rotate in the same direction with a cycling probability of about 10^{-9}. Finally, because the motor has no thermally induced step, the efficiency and unidirectionality increase on lowering the temperature. *AM*

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METAL-ORGANIC FRAMEWORKS

Sustainable cooling

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Climate control systems consume lots of energy — more than 44% of total energy used in US homes, for instance — so the development of sustainable adsorption heat pumps (AHPs) is urgent. Water is considered to be an ideal refrigerant to replace hydrofluorocarbons, but its development is hindered by the low adsorption efficiency and large size of current AHPs. Recent interest has focused on using metal–organic frameworks (MOFs) for AHPs because they offer accurate control over water uptake over a range of relative humidity. Now Dincă et al. from MIT report cascaded AHPs based on tunable MOFs with improved efficiency at lower source temperature. Moreover, water is used as the only refrigerant.

They choose Ni_2Cl_2BBTA (BBTA is 1H,5H-benzo(1,2-d),(4,5-d′)-bistriazole) to construct the AHPs and find that Ni_2Cl_2BBTA has a high working capacity, able to produce a lift of 25 °C in a single-stage AHP. Usually, multiple-stage cascaded cycles work better because the input thermal energy for regeneration can be used twice. They use this in tandem with another thermodynamically tunable MOF adsorbent, Co_2Cl_2BTDD. The small-pore Ni_2Cl_2BBTA and large-pore Co_2Cl_2BTDD have non-overlapping water isotherms, enabling continuous cooling with much higher efficiency. A coefficient of performance of 1.63 is achieved with a low driving temperature of 127 °C. *WS*

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REGENERATIVE MEDICINE

Nerve bridge

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Regenerative medicine approaches to treat spinal cord injuries (SCI) rely on engineered biomaterials that aim to reproduce the conductivity and mechanical properties of the native tissue, while promoting nerve regeneration. Various soft conductive hydrogels have been fabricated to this aim, but most are composed of a mesh of conductive polymers embedded in non-conductive hydrogels. This results in sub-optimal conductivity and risk of component leaching on swelling under physiological conditions.

Now Zhou et al. synthesize a highly conductive microporous soft hydrogel made of polypyrrole cross-linked and doped with tannic acid. When implanted in a mouse model of SCI, the material easily adheres to spinal cord tissue, restoring the interrupted electric signals in the area of a lesion and promoting neurogenesis. Cell infiltration in the micropores of the hydrogel contributes to tissue regeneration, and the anti-inflammatory characteristics of tannic acid prevent inflammation. Animals implanted with the conductive hydrogel display improved recovery of motor skills over the course of 6 weeks. *CP*

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