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quantum teleportation applications. As reported in the October 1 issue of *Optics Letters* (p. 2635), Raphael C. Pooser and Olivier Pfister of the University of Virginia have demonstrated that a modified KTiOPO_4 (KTP) crystal can be used to mediate multiple nonlinear optical processes simultaneously, potentially allowing it to act as the heart of a many-mode CV entanglement source.

The generation of two CV-entangled modes (bipartite entanglement) is accomplished by first creating two "squeezed" beams in an optical parametric oscillator (OPO) operating just below threshold. These beams, which display reduced fluctuations in one particular phase combination of the electric and magnetic field, are next overlapped on a 50/50 beam splitter. The two output beams of the beam splitter are CV-entangled and can be used for quantum encryption or quantum teleportation. To increase the number of parties participating in the encryption or teleportation scheme, researchers at the University of Tokyo recently built a tripartite (three-mode) CV entanglement source using three separate OPOs whose outputs were made to stably overlap on multiple 50/50 beam splitters. Earlier work by Pooser, Pfister, and their colleagues showed that tripartite CV entanglement could be achieved using only a single OPO, if the nonlinear crystal at the heart of the OPO could be engineered to constructively enhance, or phase-match, two different nonlinear optical interactions simultaneously.

For the study reported in *Optics Letters*, Pooser and Pfister used a 7 mm crystal of periodically poled KTP with a carefully chosen 45.65 μm period. As predicted by theory, when pumped with light at 1.49 μm , the crystal displayed simultaneous phase-matching for three independent nonlinear processes (two second-harmonic generation processes and one sum-frequency generation process), sufficient in principle for as much as quadripartite (four-mode) CV entanglement. This rare "triple coincidence" suggests that complex multipartite CV entanglement sources based on only a single OPO are feasible with the appropriate crystal engineering. Such sources could ultimately become critical components in applied quantum encryption and quantum teleportation systems.

COLIN MCCORMICK

SAMs Serve as Templates for Patterned Growth of Large Oriented Organic Semiconductor Single Crystals

Organic electronic devices fabricated from high-quality single crystals of organic semiconductors have increased mobility due to the lack of grain boundaries and molecular disorder. One of the challenges that limits application of single-crystalline organic semiconductors is the fragility of the crystals, which creates problems in handling them. If the oriented single-crystalline organic semiconductor could be selectively grown directly in the designated locations in a device structure, this problem could be solved. Recently, a group of researchers in the University of California at Los Angeles, Lucent Technology, and Stanford University have made progress toward this goal. As reported in the September issue of the *Journal of the American Chemistry Society* (p. 12164; DOI: 10.1021/ja052919u), A.L. Briseno of UCLA, J. Aizenberg of Lucent, Z. Bao of Stanford, and their colleagues have demonstrated a method for inducing site-specific growth of large oriented organic semiconductor crystals using micropatterned self-assembled monolayers (SAMs) bearing regions of oligophenylene thiols as nucleation templates.

The researchers first tested the ability of different SAM-modified gold substrates to serve as templates for the formation of organic semiconductor crystals using a solvent evaporation method. They immersed substrates modified with SAMs of alkanethiols bearing methyl ($-\text{CH}_3$), terphenylthiol ($-\text{3P}$), and other oligophenylene thiols in a saturated anthracene/THF solution and allowed them to evaporate over several days. They

then performed x-ray diffraction measurements and molecular modeling to demonstrate that the $-3P$ SAM matched the molecules' orientation and the packing of the nascent anthracene crystal in the c^* -direction. Thus $-3P$ SAMs are a nearly perfect template for the oriented nucleation of the anthracene crystals from the (001) plane. On the other hand, $-CH_3$ SAMs have the least nucleation density of anthracene crystals and the least surface coverage.

The researchers then addressed the possibility of controlling the location and the pattern of nucleation. To achieve a better selectivity of patterned growth, they designed the template with SAMs of two extremes bearing $-CH_3$ and $-3P$. The research team used the micro-contact printing (μ CP) method to make micropatterned substrates with regions of $-3P$ and $-CH_3$ having different geometries and relative sizes. The team used both solvent evaporation and dip-coating methods to achieve selective growth of organic semiconductor molecules. The researchers observed highly localized crystal growth onto regions patterned with oligophenylene thiols. The surface coverage of crystals grown on micropatterned $-3P$ regions increased to $>95\%$ versus 23% for the unpatterned $-3P$ substrates. Using this method, the researchers obtained large oriented single crystals of anthracene overgrowing the entire underlying $100\ \mu\text{m} \times 100\ \mu\text{m}$ square regions of $-3P$. The researchers said that the flux of molecules to the growing crystals in the $-3P$ region will induce near-surface concentration gradients and deplete anthracene molecules from the less active alkylthiol areas. This is a promising way to achieve highly selective patterned growth of single-crystalline organic semiconductor with increased surface coverage, they said.

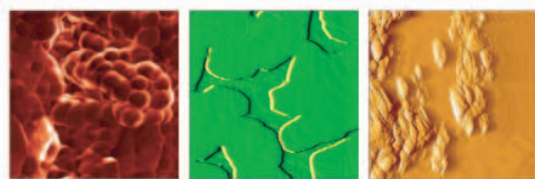
TAO XU

Light-Induced Effects Dominate Transconductance in OFETs

The physics of photoinduced charge transfer across organic interfaces in organic field-effect transistors (OFETs) is not well known, but is crucial to the development of devices such as active-matrix displays. Two researchers, V. Podzorov and M.E. Gershenson, from Rutgers University have now published their results for a mechanism of photoinduced charge transfer across the interface between an organic semiconductor (rubrene) and a polymer (parylene). In their article in the July 1 issue of *Physical Review Letters* (#016602), the researchers said that their discovery could be crucial for understanding optoelectronic devices such as active-matrix displays. They carried out their experiments on single-crystal rubrene OFETs with parylene as the gate dielectric. The researchers said that the front-gate FET design with a transparent dielectric and semitransparent gate electrode allows them to study the light-induced effects at the organic molecular crystal (OMC)–polymer interface over a wide spectral range that includes the absorption band of OMC.

In the dark, the "as-prepared" single-crystal rubrene OFETs exhibit a very small field-effect threshold. The researchers said this indicates that the density of deep traps at the OMC–parylene interface does not exceed $10^{10}\ \text{cm}^{-2}$. Prolonged application of the gate voltage (V_g) in the dark does not affect the dependence of the source–drain current (I_{SD}) on the gate voltage (V_g), (i.e., the transconductance), they said. However, illumination of the OFETs with a visible light at a fixed gate voltage results in a shift of the dark transconductance characteristics toward lower or higher V_g . The shift is characterized by the magnitude of the field-effect onset voltage (V_{onset}). The photoinduced V_{onset} shift is preserved in the dark for days regardless of further measurements at different V_g . The researchers said that the observed photoinduced shift of V_{onset} is caused by the charging of the gate dielectric with the non-equilibrium carriers, photogenerated in the rubrene near the interface, and transferred into the polymer.

The researchers concluded that two conditions are required for the charge transfer: photoexcitation with a photon energy greater than the highest occupied molecular orbital–lowest unoccupied



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