in Munich, the Fraunhofer Institute for Solar Energy Systems in Freiburg, and The Max Planck Institute for Polymer Research in Mainz say that this advance significantly reduces the lasing threshold and improves the efficiency of organic laser devices. These results were announced in the September 11 issue of *Applied Physics Letters*.

A mechanically flexible poly(ethylene terephthalate) (PET) substrate with an acrylic coating was embossed with a 2D periodic height modulation nanopattern using ultraviolet (UV) radiation. The active laser material, a ladder-type poly(p-phenylene) (LPPP), was then deposited in a 300-nm thick layer on this substrate by spincoating. A Ti:sapphire laser producing pulses of approximately 150 fs duration at a wavelength of 400 nm was used for excitation. When focused to a spot approximately 150 μm in diameter on the LPPP surface, nearly diffraction limited monomode laser emission was observed perpendicular to the surface above a pump pulse energy of 1.2 nJ. The 2D photonic bandgap structure significantly limits lasing from other lateral modes. The peak intensity of the emission occurred at 491 nm. Comparison of the 2D laser with a one-dimensional (1D) periodic height modulated laser of the same maximum amplitude showed a dramatic increase in the emission intensity in the 2D case, as well as a 30% reduction in the laser threshold energy. Also, the divergence of emission was drastically reduced in the 2D laser, resulting in highly directed nonpolarized emission.

The researchers explain the observed effects in terms of the Laue formulation for the feedback mechanism in a 2D photonic band structure, involving elastic Bragg scattering to couple wavevectors having the same energy.

TIM PALUCKA

Bottom-Gate Geometry Increases Materials Options in All-Polymer Integrated Circuits

Investigators at the Philips Research Laboratories in The Netherlands have shown that bottom-gate structures for organic field-effect transistors open the door to a wide variety of polymeric materials, including the high mobility semiconducting materials pentacene and regioregular poly(3-hexylthiophene), or P3HT. Reporting in the September 4 issue of *Applied Physics Letters*, G.H. Gelinck, T.C.T. Geuns, and D.M. de Leeuw also demonstrated that low-ohmic vertical interconnects (vias) between the top and bottom layer can be etched photochemically, making eventual scaling up of the technology feasible.

Top-gate structures sandwich the semiconductor between the first electrode and the gate dielectric, imposing materials compatibility restraints on the organic semiconductor employed. Previous work using a top-gate electrode with polythienylenevinylene (PTV) as the semiconductor resulted in transistors with low field-effect mobilities (approximately 1×10^{-3} cm^2/Vs). Since the semiconductor is not sandwiched in the bottom-gate structure, materials compatibility is a lesser concern; high mobility organic

SBIR Update

Diversified Technologies, Inc. (Bedford, Massachusetts) has been awarded $3,000,000 under a total of six Phase I and Phase II Small Business Innovation Research (SBIR) grants from the Department of Energy to extend the firm's PowerMod™ solid-state high power electronics technology to higher voltages and currents, and achieve faster switching times.

Advanced Refractory Technologies, Inc. (Buffalo, New York) has been awarded a $750,000 Phase II SBIR contract from the U.S. Marine Corps for the development and implementation of a lightweight/durable aluminum metal matrix composite track system for the Advanced Amphibious Assault Vehicle.

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semiconductors become viable, and standard solution-processing techniques can be used.

In this study the researchers investigated devices made from pentacene, PTV, and P3HT. Electrodes and interconnect lines were photochemically patterned on glass or 50-μm thick polyimide foils using 200-nm thin polyaniline (PANI) films. A 300-nm thick layer of commercially available photoresist compound was deposited on the first layer by spincoating, creating the gate dielectric and insulation for the interconnect lines. Contact holes were masked into the photoresist layer. Finally, the source and drain electrodes were masked into the top PANI layer; after spincoating, a low-ohmic via (typically < 1 kΩ) formed between the top source and drain electrodes of one transistor and the bottom-gate electrode of another. Top-gate devices fabricated for comparison using the same methods yielded vias with resistance values in the MΩ range.

The pentacene transistors gave the best results, with mobilities in the range of 1×10^{-2} cm^2/Vs, versus 3×10^{-3} for P3HT and 1×10^{-3} for PTV. A programmable code generator was fabricated combining over 300 transistors and 200 vias to form a clock-generator, a 5-bit counter, a decoder logic function, and 15 program pads in one integrated circuit. Again, the pentacene device performed best, achieving a transmission rate of 100 bit/s. Further research to improve the shelf life of these organic semiconductors is needed before practical devices can be achieved.

TIM PALUCKA

Quasicrystal-Filled Polymers Outperforms Other Polymer Composite in Wear-Resistance Properties

Valerie Sheares, a researcher at Ames Laboratory and assistant professor of chemistry specializing in polymer research at Iowa State University, has combined quasicrystals and polymers in a composite that outperforms similar materials in wear-resistance tests. In addition to the improved performance of the polymers, the composite offers a more versatile way of using quasicrystalline powders, which could make the materials more appealing to industry.

"It's a unique material," said Sheares, who has applied for a patent on the quasicrystal-filled polymers. "It's very hard, it's not abrasive, and it has low thermal conductivity."

To determine whether the wear-resistant properties of quasicrystals had transferred to the composite, half-dollar-sized disks of the material were placed on the turntable of a wear-testing device and a small stainless-steel ball was placed in the device's arm. A weight of 1–2 pounds was attached to the middle of the arm to hold the ball in contact with the composite material as the disk spun at a rate of 125 rpm.

Afterwards, the disks and the steel balls were examined to determine how much of each surface had worn away. Results indicated that the quasicrystal-filled polymers were between five and 10 times better in resisting wear than any other polymer or polymer composite that was tested.

Even more significant was the near-perfect condition of the steel ball. "As hard as quasicrystals are, you have to wonder what happens to the other surface scraping against it," Sheares said. "Quasicrystals outperform every other hard filler in that the steel ball remains basically unchanged. When we tested silicon-carbide fillers, the surface of the ball was completely eroded away because silicon carbide is hard and abrasive. Quasicrystals are hard and nonabrasive. Those two things don't usually go together."

Since polymer-processing techniques are already well-known, Sheares said the

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