Optical Amplification Achieved in a First-Generation Dendritic Organic Semiconductor

Since the discovery of their light-emitting properties, organic semiconductors have stimulated great interest within the display industries and opened opportunities for other optoelectronic devices, such as visible laser diodes and, most recently, optical amplifiers.

There are three main classes of light-emitting organic semiconductors, of which the youngest technology is conjugated dendrimers—a family of highly branched molecules. In a dendrimer, the molecular branches form a snowflake-like structure that converges to a single focal point or core. This type of structure allows for the independent tuning of the electrical, optical, and processing properties of the material.

As reported in the April 15 issue of *Optics Letters*, researchers J.R. Lawrence of St. Andrews University, G.J. Richards of Oxford University, and their colleagues have observed strong optical amplification of violet light in both the liquid and solid states of first-generation bis(fluorene)-cored semiconducting dendrimers. The core, consisting of a bis(fluorene) unit capped with two first-generation triphenyl-based dendrons containing 2-ethylhexyloxy surface groups, was made by using palladium catalysis to couple the first-generation boronic-acid-focused dendron with 7,7′ dibromobisfluorene. The liquid optical amplifier was based upon a solution of dendrimer mixed with toluene. The solid-state optical amplifier was made by spin-coating the dendrimer solution onto quartz substrates to produce slab waveguides in 200-nm-thick films. The researchers used a 337 nm wavelength, pulsed nitrogen laser as the excitation source and observed optical gains of 36 dB cm^{-1} and 26 dB cm^{-1} at 429 nm and 390 nm, respectively, in solution, and a maximum gain of 350 dB cm^{-1} at 425 nm in the solid state. These results compare well with values reported for other organic semiconducting materials. The researchers believe that dendrimers offer considerable scope for molecular designers to tune the gain across the visible spectrum, and that the solid-state form has potential for electrically pumped amplification.

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Review Articles and Special Issues

Journal of Physical and Chemical Reference Data **33** (2) (June 2004) contains A. Jablonski, F. Salvat, and C.J. Powell, "Comparison of Electron Elastic-Scattering Cross Sections Calculated from Two Commonly Used Atomic Potentials," p. 409; and S.K. Mishra, R.K.S. Yadav, V.B. Singh, and S.B. Rai, "Spectroscopic Studies of Diatomic Indium Halides," p. 453.

Journal of Applied Physics **95** (8) (April 2004) contains C.G. Van de Walle and J. Neugebauer, "First-Principles Calculations for Defects and Impurities: Applications to III-Nitrides," p. 3851.

Journal of Environmental Engineering **130** (4) (April 2004) contains the Simon W. Freese Environmental and Engineering Lecture by P. Sarin, V.L. Snoeyink, D.A. Lytle, and W.M. Kriven, "Iron Corrosion Scales: Model for Scale Growth, Iron Release, and Colored Water Formation," p. 364.

Reviews of Scientific Instruments **75** (4) (April 2004) contains R.S. Lakes, "Viscoelastic Measurement Techniques," p. 797.

Low Temperature Physics **30** (3) (March 2004) contains V.M. Loktev and V.M. Turkowski, "Doping-Dependent Superconducting Properties of Two-Dimensional Metals with Different Types of Interparticle Coupling," p. 179.

Physics of the Solid State **46** (3) (March 2004) contains A.I. Morosov and A.S. Sigov, "New Type of Domain Walls: Domain Walls Caused by Frustrations in Multilayer Magnetic Nanostructures," p. 395.

Solid State Electronics **48** (6) (June 2004) is a special issue on Silicon-on-Insulator Technology and Devices.

Journal of Materials in Civil Engineering **16** (2) (April2004) is a special issue on Micromechanical Characterization and Constitutive Modeling of Asphalt Mixes.

Journal of Microlithography, Microfabrication, and Microsystems **3** (2) (April 2004) contains a special section on Mask Technology for Optical Lithography.

IEEE Transactions on Nanobioscience **3** (1) (March 2004) is a special issue on Nanocapsules: A European Community Interdisciplinary Network in the Nanobiosciences.

Journal of Biomedical Optics **9** (2) (March, 2004) contains a special section on the Optics of Human Skin.

IEEE Journal of Solid State Circuits **39** (4) (April 2004) contains papers from the 2003 Symposium on VLSI Circuits held in Kyoto, Japan, June 12–14, 2003.

Thin Solid Films (April 2004) contains the proceedings of Symposium H on Photonic Processing of Surfaces, Thin Films, and Devices from the 2003 E-MRS Spring Conference held in Strasbourg, France, June 10–13, 2003.

Vacuum **73** (3–4) (April 19, 2004) contains the proceedings of the 4th International Symposium on Applied Plasma Science, held in Kyoto, Japan, September 1–5, 2003.

IEEE Transactions on Nanotechnology **3** (1) (March 2004) contains papers from the Second International Workshop on Quantum Dots for Quantum Computing and Classical Size Effect Circuits (IWQDQC-2), held in Notre Dame, Indiana, August 7–9, 2003.

Vacuum **73** (2) (March 19, 2004) contains the proceedings of the European Vacuum Congress Berlin 2003, featuring the 8th European Vacuum Conference, 2nd Annual Conference of the German Vacuum Society, June 23–26, 2003.

Nanopatterning on a Biocompatible Polymer Film Accomplished with UV Embossing

Affordable, large-area nanopatterning on biocompatible films is important for applications such as tissue engineering and gene and drug delivery. Poly(ethylene glycol) patterns have been produced with photolithography, but resolution is limited to about 1 μm. Electron-beam writing and focused ion-beam (FIB) lithography are both capable of the resolution required for nanopatterning, but both are serial processes (and are therefore time-consuming) and require specialized substrates. Recently, however, J.X. Gao, M.B. Chan-Park, and colleagues of Nanyang Technological University, Singapore, have developed a practical technique—a combination of FIB lithography and UV embossing—to replicate a nanopattern on a biocompatible polymer.

As reported in the March 23 issue of *Chemistry of Materials*, Chan-Park and co-workers first created a master mold by using a focused ion beam to etch a nanopattern into a 1-mm-thick titanium nitride (TiN) film. A replication of the master was made using silicone rubber. The silicone casting was then used as the mold for the UV embossing with poly(ethylene glycol) diacrylate (PEGDA) and a photoinitiator. The researchers selected TiN because it has the desired hydrophobicity and durability for multiple-use master molds. PEGDA has been

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shown previously to be biocompatible and nonadhesive to protein and cells. Details of the rubber casting and UV embossing techniques were previously published.

The researchers found that the TiN mold can be used for more than 20 rubber castings without much dimensional change, which they attribute to the low surface energies of both TiN and silicone. Scanning probe microscopy (SPM) analysis shows that the roughness of the TiN master is about 4 nm, which the researchers present as evidence that FIB lithography of TiN produces surfaces smooth enough for nanopatterning. Similarly, successive generations of rubber moldings display little dimensional difference. However, scanning electron micrographs show that the structure resulting from the eighth consecutive PEGDA embossing (from the same silicone mold) displays some surface defects, although the major dimensions are replicated well. The researchers believe that increasing the hydrophobicity of the silicone and/or PEGDA can minimize surface defects.

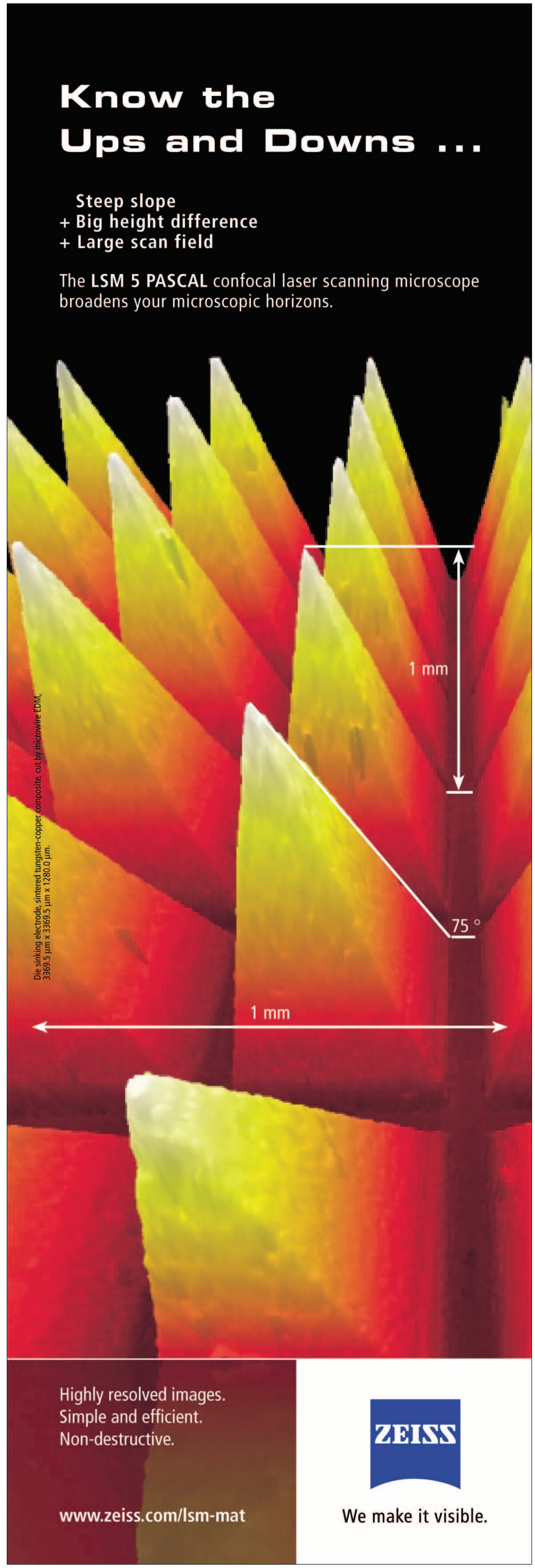
The researchers said that their technique is inexpensive and requires no special processing conditions, thereby allowing several tens to hundreds of UV-embossed PEGDA replications to be easily made from a single submicrometer-patterned TiN master mold.

STEVEN TROHALAKI

Theoretical Simulation of Laser Emissions Describes Intensity and Polarization Properties of Semiconductor Nanowires

Nanowires, which can have diameters of 20–200 nm, are capable of laser emission through the axial direction. While the smaller-diameter nanowires can only support emission with a mode similar to the fundamental hybrid mode of optical fibers, larger-diameter nanowires can give rise to different coexisting modes. Information on the properties of the far-field radiation is necessary to reveal the particular mode type involved. As a first approach toward analyzing the emissive modes of nanowire lasers, A.V. Maslov and C.Z. Ning from the Center for Nanotechnology at NASA Ames Research Center in California have developed a theoretical methodology to establish the mode type, deduced from the characteristics of the corresponding far-field radiation. They presented their research in the March 15 issue of *Optics Letters*.

Maslov and Ning applied the finite-difference time-domain method to formulate their simulation. Initially, a current source excited two wave packets that traveled along the length of a vertically oriented nanowire toward the two ends of the nanowire, respectively. In their discussion, the researchers assumed that in a self-supporting nanowire in a steady-state regime, it was adequate to consider only the radiation that is incident on the top end. They then defined a domain using cylindrical coordinates: 100 cells in the ρ direction, 600 cells in the z direction, and a radius of 10 cells. After an excited wave packet arrived at the top of the nanowire, part of it was reflected, and the remainder left the nanowire so that an electronic field with two components, E_θ and E_ϕ, was created in the far-field region, where θ is the polar or elevation angle with respect to the z axis and φ is the azimuth angle. These were calculated by integrating an expression for the equivalent current on the surface that surrounds the source of the fields. The value of the dielectric constant was assumed as 6, typical of nanowire materials such as GaN, ZnO, and CdS at emitting frequencies. The researchers then analyzed the spectral density of the emitted radiation. Analysis of the resulting expressions was related to the polarization properties by considering the symmetry of the calculated far-field patterns. For example, the transverse magnetic-field polarization (TM_{01}) mode had only an E_θ component, the transverse electric-field polarization (TE_{01}) mode had only an E_ϕ component, and the HE_{11} mode (i.e., the fundamental hybrid mode) had both E_θ and E_ϕ components.



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