**femtosecond lasers manipulate subcellular structures**

Organelles and other subcellular structures are the machinery by which cells carry out their basic functions. Cellular biologists typically use biochemical and genetic techniques to change one structural protein at a time when investigating subcellular structures and their effect on the cell’s operation. However, because of the complexity of the biochemical and genetic processes in a cell, it is difficult to isolate subsequent effects caused by the chemical or genetic change with a high degree of certainty.

Photonic techniques such as fluorescence microscopy and laser tweezers have allowed cellular biologists to manipulate cells in the past but not to remove subcellular structures without harming the overall cell.

Epifluorescence microscope image of mitochondria before and after laser disruption. By using an impermeable dye, ethidium bromide, that can only enter a cell with a damaged cell membrane, researchers can eliminate internal subcellular structures without harming the overall cell.

**programmable OLEDs change color**

Programmable emission wavelengths in organic light-emitting diodes (OLEDs) could simplify manufacturing and open up new applications such as data storage. Researchers at the National Taiwan University (NTU; Taipei, Taiwan) created an electrically programmable OLED by incorporating a thin carrier-blocking layer as the sacrificial fusing layer. The group’s OLED is transformed from a blue-emitting device to a green-emitting device, with 0.6 to 0.7% external quantum efficiency in both states (comparable to conventional devices).

Fabricated on a glass substrate, the device structure consists of a 150-Å carrier-blocking layer of bis-4,4’-[(diphenylmethylsilyl)vinyl]biphenyl (DPSVB), sandwiched between a 300-Å conducting polymer hole injection layer of polyethylene dioxythiophene/polystyrene sulphonate (PEDT/PSS), a 600-Å hole transport layer of α-naphthylphenylbiphenyl diamine (α-NPD), and a 300-Å electron transport layer of tris-(8-hydroxyquinoline) aluminum (Alq3).

Because the DPSVB layer has a lower glass transition temperature (T_g) than its neighboring layers, raising the device’s internal temperature above T_g permits the inter-diffusion and consequent fusing of neighboring layers, resulting in an irreversible change in device color and electrical characteristics.

“An OLED that can be programmed to emit different colors after fabrication will simplify manufacturing of color OLED displays, because only one type of device needs to be prepared during fabrication,” explains Chung-Chih Wu of the research group. Future developments will involve investigations of OLED structures that can be programmed more than once and that can be programmed to show full colors (RGB). —Phillip Espinasse
improved SiC growth method provides basis for blue lasers

A new method for growing bulk single-crystal silicon carbide (SiC) can produce high-quality SiC wafers for optoelectronics applications, say engineers at Okmetic AB (Linköping, Sweden), a member of the Okmetic group (Vantaa, Finland). “We have been building on our long-term work with Linköping University,” says Asko Vehanen of Okmetic. “This has borne fruit in the form of a radically new method for SiC crystal growth, high-temperature chemical vapor deposition (HTCVD).” Using a continuous flow of pure gases containing silicon and carbon species, the HTCVD method produces SiC crystals with tightly controlled electrical and optical properties (see figure on page 12).

According to Vehanen, the group has developed the first high-purity semi-insulating SiC wafers. “The main advantage is a significant increase in ingot quality—micropipes, background doping levels, etc.—and the degree of process control,” says Vehanen. “We have also demonstrated SiC wafers that so far cannot be produced with sublimation, for example p-type wafers.”

Okmetic is refining its relationship with Aixtron group (Aachen, Germany) member Epigress AB (Lund, Sweden), which produces the reactors for the HTCVD process. That company also has ties to the university. “In 10 years Linköping University has developed SiC growth technologies together with Okmetic, ABB, and Epigress,” says Erik Janzén at Linköping University. “We will also expand our research on nitrides grown on SiC substrates.”

Epigress is slated to supply Okmetic with a gas foil rotation (GFR) hot-wall SiC CVD system, says Goran Berg of Epigress. This system can accommodate three 2-in. or single 3- and 4-in. wafers.

SiC is a strong contender for the development of short-wavelength, high-brightness devices, say Reed Electronics Research (Sutton, UK) analysts in Optoelectronics: A Study of the Worldwide Semiconductor Optoelectronic Component Industry 2005. “The total market for these type of devices will reach U.S. $714 million for blue lasers and light-emitting diodes (LEDs) by 2005,” the report says. “White LEDs based on these wide

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structures while leaving the rest of the cell intact. All that has changed, however. Eric Mazur and colleagues at Harvard University (Cambridge, MA) and Harvard Medical School have used tightly focused femtosecond laser pulses to vaporize individual organelles and other subcellular structures with submicrometer precision—without disturbing the rest of the cell.

“Although they've been around since the '80s, it's not until the last five years that femtosecond lasers have been simple enough to operate to encourage this kind of cross-disciplinary work,” says Chris Schaffer of the University of California at San Diego’s biochemistry department and organizer of the Commercial and Biomedical Applications of Ultrafast Lasers IV Conference at Photonics West 2002 (19–25 January; San Jose, CA), where Mazur's group will present its latest work (paper #4633-29). “Sometimes you want to genetically or immunologically affect all of one type of substructure, but other times you just want to affect a few substructures of one type within a cell and see how the rest react. This is the only way to accomplish that.”

Nan Shen, lead researcher for Mazur's group, uses a continuous-wave (CW) 5-W diode-pumped solid-state laser (Coherent Inc.; Santa Clara, CA) to pump a titanium-doped sapphire (Ti:sapphire) oscillator (Kapteyn-Murnane Laboratories L.L.C.; Boulder, CO). The setup also includes a neodymium-doped yttrium lithium fluoride (Nd:YLF) second-stage amplifier that produces a 1-kHz pulse train, but Shen intends to remove the amplifier from the setup as soon as possible and use software to control the repetition rate of the Ti:sapphire. “It's only there because we share the setup with other experiments,” Shen says. “For our purposes, we only need 2 nJ per pulse, so a second-stage amplifier isn't necessary.” An epifluorescent microscope with high numerical aperture (NA 1.4), oil-immersed objective delivers the pulses to the cell.

The trick, according to Shen, is to deliver just the right amount of energy: too much and you disrupt the entire cell, too little and the 800-nm light from the Ti:sapphire passes right through the sample. Each 100-fs pulse is focused down to an hour-glass shaped area some 400 nm in diameter at the waist and 1 µm deep. The high

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Bandgap semiconductors could add an additional U.S. $806 million by 2005."

In a related story, Osram Opto Semiconductors GmbH (Regensburg, Germany) has demonstrated a continuous-wave (CW), blue-emitting indium gallium nitride (InGaN) laser. The work is the culmination of a research project funded by the German government and includes collaborators at the Fraunhofer Institut für Angewandte Festkörperphysik (Freiburg, Germany) and the universities of Stuttgart, Braunschweig, and Ulm.

Success did not happen overnight. “Even the first pulsed blue laser we developed in our labs in Regensburg represented a huge success for us,” recalls Alfred Lell, project manager for the blue laser project at Osram Opto. The laser emitted microsecond pulses at approximately 410 nm but required a current of 1200 mA and a voltage of 33 V.

“This corresponds to an electric power of around 40 W, and a lot of heat is generated in the process,” says project coordinator Volker Härle of Osram Opto. “In order to achieve a CW blue laser, we had to find ways and means to reduce the current, voltage, and therefore the power required to operate the laser.”

To build the 0.5-mm × 0.3-mm × 0.1-mm laser chip, the group deposited various layers onto the SiC substrate using metal-oxide vapor phase epitaxy (MOVPE). Reducing the threshold current of the laser was a key step to reducing power consumption. It became evident that one efficient way of doing this was to optimize the InGaN quantum well (QW) active zone in which the light is generated. Specific coordination and adaptation of the composition and the thickness and the spacing of the QWs, combined with a precise definition of their quantity, ultimately led to success. With the aid of ridge waveguide technology, it was possible to limit the light-emitting range to a width of 3 µm, thus keeping the threshold current within defined limits.

—Roy Szweda

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A NA lens creates an 80° cone angle for each laser pulse, compressing the bulk of the laser light to a focal point smaller than the wavelength of the laser light. The sheer number of photons at the focal point encourages nonlinear multi-photon absorption of the photons by the electrons in the subcellular structure. After a few pulses, enough light is absorbed to either vaporize or disrupt the structure. Shen can then view the results on the epifluorescent microscope or take the sample to a nearby lab for confocal imaging.

Early results are encouraging. With greater control of the pulse repetition rate, Shen intends to move from epifluorescent imaging to a high-resolution real-time multi-photon microscope, using some of the pulses for disruption and the rest to excite longer-lived fluorescent dyes that will allow her to watch the disruption in real time.

“There are confocal microscopes that operate at full video rate,” Schaffer adds. “All the pieces are there to watch cell repair mechanisms and intracellular signal transduction processes in real time.”

—Winn Hardin

**detectors**

**accident halts KamLAND**

Yoji Totsuka, director of the Kamioka Observatory (Kamioka, Japan), confirms that a severe accident damaged a significant part of the Super-Kamiokande detector, which is designed to track the elusive neutrino. Located a mile deep in an abandoned zinc mine 180 miles northwest of Tokyo, the detector consists of a tank holding 12.5 million gallons of pure water and is lined with 11,242 photomultiplier tubes spaced about 1 m apart (see oemagazine, June 2001, page 20). These tubes detect a bluish streak of light in the water when a high-speed particle passes through. The accident reportedly occurred as the water in the tank was being changed, but the exact cause is...