size, and cost, the same laser beam would be used for both conoscopic holography and Raman spectroscopy. The two-laser configuration would be preferable in cases in which the illumination needed for Raman excitation significantly exceeds that needed for conoscopic holography and, hence, it becomes necessary to alternate between conoscopic and Raman analysis of each scan spot.

The proposed instrument would be capable of mapping topography and chemical composition at lateral scales from microns to meters, with nanometer height resolution. Thus, the instrument could provide information on composition, roughness, porosity, and fractal dimension of specimens ranging from fine dust to large rocks, without need for any preparation of the specimens. The instrument would be mechanically noninvasive in that there would be no need for mechanical contact between a solid probe and a specimen. Because the probe would be a narrow laser beam, it would be possible to profile features at the bottoms of steep, narrow holes — for instance, crevices in a rock. The proposed instrument could also be combined with other optical spectroscopic instruments.

This work was done by Mark S. Anderson of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to NPO-30751, volume and number of this NASA Tech Briefs *issue, and the page number.*

Adding GaAs Monolayers to InAs Quantum-Dot Lasers on (001) InP

Modifications enable long-wavelength lasing at higher temperatures.

NASA's Jet Propulsion Laboratory, Pasadena, California

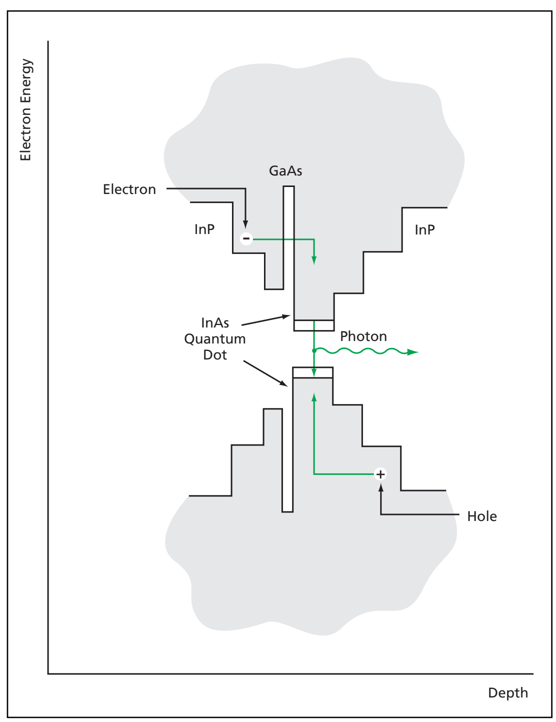
In a modification of the basic configuration of InAs quantum-dot semiconductor lasers on (001)InP substrate, a thin layer (typically 1 to 2 monolayer thick) of GaAs is incorporated into the active region. This modification enhances laser performance: In particular, whereas it has been necessary to cool the unmodified devices to temperatures of about 80 K in order to obtain lasing at long wavelengths, the modified devices can lase at wavelengths of about 1.7 μm or more near room temperature.

InAs quantum dots self-assemble, as a consequence of the lattice mismatch, during epitaxial deposition of InAs on $In_{0.53}Ga_{0.47}As$/InP. In the unmodified devices, the quantum dots as thus formed are typically nonuniform in size. Strain-energy relaxation in very large quantum dots can lead to poor laser performance, especially at wavelengths near 2 μm, for which large quantum dots are needed. In the modified devices, the thin layers of GaAs added to the active regions constitute potential-energy barriers that electrons can only penetrate by quantum tunneling and thus reduce the hot carrier effects. Also, the insertion of thin GaAs layer is shown to reduce the degree of nonuniformity of sizes of the quantum dots.

In the fabrication of a batch of modified InAs quantum-dot lasers, the thin additional layer of GaAs is deposited as an interfacial layer in an InGaAs quantum well on (001) InP substrate. The device as described thus far is sandwiched between $InGaAsP_y$ waveguide layers, then further sandwiched between InP cladding layers, then further sandwiched between heavily Zn-doped (p-type) InGaAs contact layer.

Once a wafer comprising the layers described above has been formed, the wafer is processed into laser diodes by standard fabrication techniques. Results of preliminary tests of experimental modified quantum-dot lasers have been interpreted as signifying that these devices lase at wavelengths from 1.60 to about 1.74 μm. The devices were found to be capable of continuous-wave operation at temperatures up to 260 K and pulse operation (duration 1 ms, repetition rate 1 kHz) at temperatures up to 280 K. It is anticipated that future such devices containing multiple stacks of quantum dots (instead of single stacks in these experimental devices) would be able to lase, at a wavelength of 2 μm. In addition, the multiple-stack devices are expected to perform better at room temperature.

This work was done by Yueming Qiu, Rebecca Chacon, David Uhl, and Rui Yang of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-40243



This Energy-Band Profile of a modified $In_xGa_{1-x}As$/InP quantum-dot structure shows the energy effect of the additional thin GaAs layer.