Intersubband quantum-box lasers: An update

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Semiconductor lasers whose active region is composed of a 2D array of intersubband quantum boxes (IQBs) hold the promise[1] to be significantly more efficient and reliable than multi-stage intersubband lasers (i.e., quantum-cascade lasers). That is a direct consequence of the fact that the electron-relaxation times in deep, unipolar QBs are at least a factor of 20 times larger than in quantum wells, as experimentally confirmed by several groups.[2]

We have reported[3] on efficient 4.7 μm emission from deep-well, GaAs-based single-stage devices. Electron-beam patterning and transfer to SiO_2 has provided 33 nm-diameter disks on 80 nm centers, to be used as the mask for IQB fabrication via *in-situ* gas etching and regrowth in an MOCVD crystal-growth system.

Key issues related to the fabrication of IQBs have been addressed and resolved. We have achieved controlled *in-situ* etching and regrowth of high-crystalline-quality, high-resistivity GaAs in 40 nm-deep trenches. While intersubband-transition devices are by and large not affected by the presence of exposed surfaces, that is not the case at the nanoscale level, since Fermi-level pinning can lead to full depletion of the devices. Etch-and-regrowth experiments have been carried out on (110)-oriented GaAs substrates, which basically correspond to the IQB edges. Special treatment of dry-etched surfaces followed by *in-situ* gas etching and regrowth has led to the elimination of charge-trapping states at the interfaces, and thus to the elimination of Fermi-level pinning for the proposed IQB-device fabrication.

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