Introduction to the Feature Issue on Mid-Infrared Quantum-Cascade Lasers

SEMICONDUCTOR lasers were invented in 1962, followed by the demonstration of double-heterostructure and quantum-well lasers. Recently, the realization of quantum-cascade (QC) lasers is another exciting development in semiconductor bandgap engineering. A type-I QC laser uses the injection of a single carrier type (electrons) into the conduction band without the involvement of holes. New physical phenomena, such as the intrinsic broad bandwidth without relaxation oscillations and an extremely narrow linewidth, exist in these lasers. Type-I QC distributed-feedback (QC-DFB) lasers have also been realized. A type-II interband QC laser, on the other hand, preserves the electron-hole recombination nature for photon emission and circumvents the fast phonon scattering loss in intraband QC lasers. Both type-I and type-II mid-IR QC semiconductor lasers can be used in important applications in bio-chemical trace gas sensing, medical diagnostics, free-space communications, and IR counter measures.

In this feature section, we have seven invited papers written by authors who have made pioneering contributions to the field. The first three cover the physical principles, historical developments, and recent breakthroughs in type-I QC lasers. Capasso *et al.*start with a brief history, fundamental physics, new designs, and a few highlights of QC lasers, including mid-infrared wireless communication links. Faist *et al.*and Sirtori *et al.*cover recent achievements, including high-power, high-temperature operation, as well as discuss the physics, technology, and future prospects of QC lasers. The next paper, by Yang *et al.*, provides a comprehensive overview of the history, realization, device performance, and advancement of type-II QC lasers. The last three papers deal with QC-DFB lasers, another major achievement in the field. The paper by Gmachl *et al.* presents detailed design physics and device performance of QC-DFB lasers, which have been successfully shown to operate as ultra-high precision spectroscopic sources for mid-infrared gas sensing, as is well described in the following paper by Kosterev and Tittel. The last paper, by Vurgaftman and Meyer, deals with a new design (and analysis) of photonic-crystal QC-DFB lasers. We believe that many more exciting and novel developments will continue to appear in this field.

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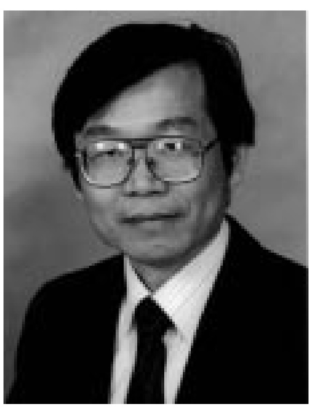

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