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Semiconductor lasers/Lasers semiconducteurs

Foreword

In the 40 years of existence of semiconductor lasers, the Physicist and the Engineer have never stopped competing for the leading position in the field. It is fair to say that neither of them has ever achieved a decisive lasting advantage, even nowadays when the semiconductor laser industry has become a multibillion market. If we look at an oversimplified picture, we could describe the 1960s as the time when the two basic concepts of population inversion in semiconductors and of heterostructures were born and brought up, the 1970s as the years when the modern techniques of epitaxial growth became a reality and made quantum wells a practical possibility, the 1980s marked by physics of low-dimensional structures and by new surface emitting laser concepts, and the 1990s as a time of technological breakthroughs such as tunable lasers, reliable facet coatings, and quantum dot self-assembly techniques.

In fact, this continuous rivalry between physics and technology has been the best guarantee of a steady flow of advances that have kept semiconductor laser research moving on, with an ever increasing impact on industry and the economy. Today as yesterday, it is difficult to foresee from which discipline the next decisive step forward is going to come. It could be from the advances in modern quantum optics, or from recent developments in semiconductor, many-body physics. It could as well come from progress in nanoscale fabrication tools, or from improved simulation capabilities; or simply from some bright idea to solve a practical problem encountered while developing one of the countless new applications of the device.

The last years have seen many exciting developments such as the progress of unipolar quantum cascade lasers, the emergence of multi-wavelength lasers, and the start of an ongoing quest for a practical, compact single-photon or twin-photon source. Made possible by improved technological mastery, there was also a come-back of older concepts such as lateral mode control for high-brightness high power lasers, or integrated sources based on non-linear optics phenomena.

This special issue is aimed at covering the most active research topics and recent developments. All papers are invited papers given by authors who are leading contributors to their field. Each of them reviews one of today's hot topics and provides both state of the art and future perspectives. Reithmaier et al. describe in depth the recent advances of quantum-dot lasers that have been made possible by the discovery of self-assembled quantum dot growth techniques. Joullié et al. give a full comparison of the various solutions competing for the coverage of the 2 to 5 µm wavelength band. In fact the 3 to 5 µm laser emission at room temperature has not yet been achieved, resisting attempts from interband lasers on the short wavelength side and from intersubband quantum cascade lasers on the long wavelength side. Recent progress of quantum cascade lasers is reviewed by Sirtori et al. These lasers have been demonstrated today in a very wide wavelength range from the mid-infrared to the THz region. They have an enormous potential for high speed modulation and for high spectral purity. Wenzel et al. review the basic concepts available to improve the brightness of semiconductor laser chips, with particular emphasis on modelling and the technology of lasers with tapered-gain regions. These provide today the highest brightness for a semiconductor source with continuous emission in the visible and near infrared spectral range. Jiménez covers the crucial issue of laser diode reliability. He analyses the various physical mechanisms responsible for appearance or movement of crystal defects and presents the current understanding of observed degradation modes. Sagnes et al. summarize recent work on the search for InP-based vertical cavity surface emitting lasers (VCSEL) at 1.55 µm and describe several successful approaches to design micro-electro-mechanically wavelength tunable sources. Blin et al. give a full account of the many phenomena occurring when influencing the phase and spectral properties of a single mode semiconductor laser by a weak optical injection. New methods are described to use the laser as an amplifier of weak signals or to realise chaos synchronisation. Finally Berger et al. review recent developments of single photon and twin photons semiconductor sources, that are eagerly expected in order to fulfil the impressive theoretical predictions made in the field of quantum information.

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Overall the collection of papers in this special issue provides a general overview of recent research developments in the field of semiconductor lasers. In any case, we hope that it will convey to our reader a feeling for the liveliness of this fascinating topic and hopefully show a few open routes where the future of semiconductor laser physics might lie.

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