

## Round-Robin measurements of linewidth enhancement factor of semiconductor lasers in COST 288 action

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## Round-Robin Measurements of Linewidth Enhancement Factor of Semiconductor Lasers in COST 288 Action

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All Authors take part in the EU COST 288 Action "Nanoscale and Ultrafast Photonics". For the complete list of affiliations, see: [http://www.unipv.it/optoele/Giuliani/alpha/paperCOST288\\_CLEOEU\\_2007.html](http://www.unipv.it/optoele/Giuliani/alpha/paperCOST288_CLEOEU_2007.html)

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**Abstract:** Round-Robin measurements on the linewidth enhancement factor are carried out in many laboratories participating to EU COST 288 Action. Up to 7 different techniques are applied to DFB, VCSELs, QCL, and QD lasers, and results are compared.

The linewidth enhancement factor ( $\alpha$ -factor) is one of the main features that distinguishes semiconductor lasers (SLs) from other types of lasers. The  $\alpha$ -factor influences the linewidth, chirp under current modulation, mode stability, laser dynamics, operating regimes in presence of optical feedback and injection, the occurrence of filamentation in broad-area devices.

As reported by Osinski and Buus [1], several different techniques have been proposed to measure the  $\alpha$ -factor, without a thorough comparison between the results achieved by different methods. This statement is even more meaningful today, as the number of proposed measuring methods has increased, and many new SL designs have been demonstrated, for which the experimental determination of the  $\alpha$ -factor can be critical (e.g., VCSELs, Quantum Dot Lasers, Quantum Cascade Lasers).

The COST 288 Action "Nanoscale and Ultrafast Photonics" [2] is an initiative sponsored by the European Commission and the European Science Foundation, within the frame COST – "European Cooperation in the field of Scientific and Technical Research". In Working Group 2 "Physics of Photonic Devices" of COST 288, a Round-Robin (RR) measurement activity centered on the  $\alpha$ -factor of SLs was started in year 2005, with scheduled end in mid-2007. The main goals are to compare different measurement methods by applying them to the same sets of devices, and to assess the accuracy and repeatability of the methods by applying them in different laboratories.

Two mainstream activities are implemented: 1) measurements on conventional telecommunication devices (i.e., commercial high-power third-window DFB laser); 2) measurements on novel structures (VCSELs, QCLs, QDs).

For the first activity, seven methods have been applied: *Hakki-Paoli* (sub-threshold spectra); *linewidth* (fitting to Henry's formula); *modified linewidth* (below- and above- threshold); *FM/AM* (high-frequency modulation); *fiber transfer function* (chirp measurement); *optical injection* (master-slave locking); *optical feedback* (self-mixing).

The complete set of results will be made available on the COST 288 website [2]. Preliminary results can be summarized as follows. (i) The Hakki-Paoli method is difficult to be applied to commercial DFBs, due to the lack of knowledge of laser parameters. (ii) The FM/AM method requires modulation well above the relaxation frequency of the SL, and it can be difficult to be implemented with some SL types. (iii) The Fiber Transfer Function can be the most reliable, provided a precise measurement of fiber dispersion is preliminarily carried out, and the power along the fiber is controlled to avoid non-linear effects.

In the second activity, critical technical aspects have been identified, relating in particular to QD devices (for which the definition itself of the  $\alpha$ -factor is non-trivial), and QCLs. For the latter, a dependence of the  $\alpha$ -factor on the injected current is observed, and the experimental results are compared with numerical simulations based on a Keldysh nonequilibrium Green's functions approach.

[1] M. Osinski, J. Buus, "Linewidth broadening factor in semiconductor lasers - An overview", IEEE J. Quantum Electron., 23, pp. 9 - 29, 1987

[2] COST 288: <http://www.een.bris.ac.uk/cost288/home.html>, COST website: <http://cost.esf.org/>, list of Authors and affiliations for this paper: [http://www.unipv.it/optoele/Giuliani/alpha/paperCOST288\\_CLEOEU\\_2007.html](http://www.unipv.it/optoele/Giuliani/alpha/paperCOST288_CLEOEU_2007.html)