Paper 12141-30

The relevance of valence band engineering in interband cascade lasers

In person: 6 April 2022 • 16:40 - 17:00 CEST | Etoile A, Niveau/Level 1

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Abstract **Authors**

Interband cascade lasers (ICLs) are attracting more and more attention, being established as reliable mid-infrared laser sources. In particular, their low threshold current densities and low power consumption qualify them for a multitude of applications aiming for portable, miniaturized sensing systems. ICLs show a performance sweet spot around 3-4 μm and continuous-wave (cw) operation at room temperature has been shown at wavelengths from 2.8-5.6 μm in the GaSb material system. When trying to extend this range towards even longer wavelengths, several difficulties are inevitably faced. Some can partly be traced back to a still insufficient understanding of the internal device physics. Here, we report on our latest findings showing the impact of intersubband transitions in the valence band band of ICL active regions on the performance of these devices. Using a numerical model employing the eight-band k·p method, we calculate the electronic band structure of the active W-quantum well (QW) in an ICL. We then use a generalized momentum matrix element model to determine the wavelength-dependent absorption between subbands in the valence band. This model can explain all contributions to the absorption in the W-QW, regardless of the nature of the transitions, whether they are interband or intersubband. We experimentally observe a clear dependence of performance metrics on the thickness and composition of the GaInSb hole-QW. Specifically, the threshold current density Jth, and its dependence on the operating temperature, described by the characteristic temperature T0, are influenced. This is in good agreement with our model. By carefully adjusting the design of the active W-QW the intersubband absorption in the valence band can be modified and even sufficiently avoided, allowing us to enhance the ICL performance outside of the sweet spot 3-4 μm region.

Presenter

Hedwig Knötig
Technische Univ. Wien (Austria)

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Presenter/Author

Hedwig Knötig

Technische Univ. Wien (Austria)

Author

Rolf Szedlak

Technische Univ. Wien (Austria)

Author

Josephine Nauschütz

nanoplus Nanosystems and Technologies GmbH (Germany)

Author

Robert Weih

nanoplus Nanosystems and Technologies GmbH (Germany)

Author

Nikola Opacak

Technische Univ. Wien (Austria)

Author

Sven Höfling

Julius-Maximilians-Univ. Würzburg (Germany)

Author

Johannes Koeth

nanoplus Nanosystems and Technologies GmbH (Germany)

Author

Gottfried Strasser

Technische Univ. Wien (Austria)