HL 37: Thermal Properties

Time: Thursday 16:30–17:15 Location: H34

HL 37.1 Thu 16:30 H34

Thermal characterization of semiconductor membranes by Raman thermometry — •Isabell Hüllen[1], Mahmoud Elhajhasan[1], Wilken Seemann[1], Markus R. Wagner[2], and Gordon J. Callsen[1] — [1]Institut für Festkörperphysik, Universität Bremen, Germany — [2]Institut für Festkörperphysik, Technische Universität Berlin, Germany

Photonic structures like nanolasers are often based on freestanding semiconductor membranes comprising hole lattices. As a result, a high number of interfaces limits the thermal conductivity and consequently the overall device performance under high injection conditions. Thus, it remains an open task to correlate the thermal and optical characterization of photonic membranes often based on III-V semiconductors. In this contribution we follow a careful step-by-step approach to attest the suitability of Raman thermometry (RT) for a precise determination of the thermal conductivity κ. First, we analyse a well-studied bulk material like Ge to not only extract κ, but also to assess underlying errors and experimental limitations. Consequently, the RT technique is applied to Ge membranes, in preparation of the subsequent thermal characterization of photonic membranes. Here, we characterize a 250-nm-thick c-plane GaN membrane, which forms the basis for state-of-the-art nanobeam lasers. RT reveals that κ is reduced by up to one order of magnitude in comparison to bulk values. The pronounced Photoluminescence signal of our GaN membrane directly enables an alternative optical and thermal characterization, which we link to RT, aiming to bridge optical and thermal material characterization.

HL 37.2 Thu 16:45 H34

Can group IV alloys compete in thermoelectrics? — •Oliver Krause[1], Ada Chimenti[2], Omar Concepción[1], Thorsten Brazda[1], Stefano Roddaro[2], Detlev Grützmacher[1], and Dan Buca[1] — [1]Peter-Grünberg-Institute 9 (PGI-9), Forschungszentrum Jülich, 52428 Jülich, Germany — [2]Dipartimento di Fisica "E. Fermi", Università di Pisa, Largo Bruno Pontecorvo 3, 56127 Pisa, Italy

The thermoelectric effect allows the conversion of heat into electricity. A material suited for efficient thermoelectric power generation using small temperature differences with a base at room temperature is of outmost interest. The figure of merit in thermoelectrics is ZT, indicating how suited a material is for thermoelectric applications. It can be optimized by reducing the thermal conductivity k and increasing the electrical conductivity σ of a material with a large Seebeck coefficient α. Here, we investigate the potential of group-IV alloys GeSn and SiGeSn, a material system compatible to standard Si technology.

We present a study of k of crystalline GeSn alloys deposited by chemical vapor deposition. The differential 3ω technique was used to determine k electrically. Our preliminary data shows that k strongly decreases with increasing the Sn content, reaching values as low as $5\ \frac{\mathrm{W}}{\mathrm{m \cdot K}}$ at room temperature. The data are compared with previous reports of the same material using Raman thermometry. Using data of the electrical conductivity and modelling of Seeback coefficient, ZT values for both p and n type GeSn layers are calculated.

HL 37.3 Thu 17:00 H34

Anisotropy in the c-plane thermal conductivity of Gallium Nitride — •Mahmoud Elhajhasan[1], Isabell Hüllen[1], Wilken Seemann[1], Ian Rousseau[2], Nicolas Grandjean[2], and Gordon Callsen[1] — [1]Institute of Solid State Physics, University of Bremen, Germany — [2]Institute of Solid State Physics, École Polytechnique Fédérale de Lausanne (EPFL), Switzerland

The thermal characterization of modern semiconductor membranes commonly employed for photonic devices like nanobeam lasers (1D) or photonic crystals (2D), often lacks spatial resolution and appropriate quantification. However exactly these two points are relevant for the detection of e.g., thermal anisotropies, heat spots, and interfaces providing thermal resitance.

In this contribution, Raman thermometry employing one laser beam (1LRT) is used to quantify the thermal conductivity κ of 250-nm-thick state-of-the-art, c-plane GaN membranes. The same membranes are then probed by two laser Raman thermometry (2LRT) to map the temperature distribution caused by a heating laser via a second probe laser. As a result, κ is determined for all in-plane crystal directions. A particular thermal anisotropy is revealed in c-plane GaN via this direct thermal imaging technique with sub-μm spatial resolution, which compares well to ab-initio calculations.

Consequently, we outline first potential routes towards thermal optimizations of photonic nanostructures.