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**Book of Abstract
Oral Sessions**

- Tu.52 **Barth Sven**
Metastable Ge-based nanowire materials
Goethe University Frankfurt, Germany p.68
- Tu.53 **Baillard Adrien**
Al and Ga co-doping of ZnO nanowires grown by chemical bath deposition
Grenoble INP LMGP, France p.69
- Tu.54 **Alattallah Khalifah**
Development of InSb-Pb hybrid nanowire
University of Copenhagen, Denmark p.70

Metastable Ge-based nanowire materials

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Group IV elements are essential for modern standards of life including Si-based science and technology in a multitude of applications. Even though semiconductor technology based on group IV is a very mature field, the physical properties can be altered by the formation of metastable solid solutions possessing significantly altered physical properties.^[1]

The contribution will address challenges and strategies for the synthesis of metastable Ge-based solid solutions including hyperdoped compounds. In this context, the crystal growth of single crystalline nanowires (NWs) will be discussed and the changes in physical properties associated with their composition shall be highlighted.

All the crystal growth studies have been carried out at low temperatures using the solute as a metallic growth seed. Hence, this process could be described as a self-seeding of the targeted $\text{Ge}_{1-y}\text{Ga}_y$ and $\text{Ge}_{1-x}\text{Sn}_x$ solid solutions. This approach allowed the formation of highly crystalline, metastable $\text{Ge}_{1-y}\text{Ga}_y$ ($y \sim 0.03\%$) as well as $\text{Ge}_{1-x}\text{Sn}_x$ ($x = 0.13-0.28$) substitutional solid solutions.^[2,3] Generally, a homogeneous incorporation of unusually high contents of Sn and Ga in the Ge lattice has been observed with incorporation efficiency exceeding the equilibrium solid solubility up to 3-30 times.

A highlight is the transformation of Ge representing a typical indirect bandgap material into a direct bandgap material upon incorporation of 19 at% Sn. The high crystal quality and efficient incorporation following our strategy has been demonstrated for $\text{Ge}_{0.81}\text{Sn}_{0.19}$ NWs by recording their photoluminescence.^[3] The absorption and emission in the mid-IR range ($< \sim 0.55$ eV) makes $\text{Ge}_{1-x}\text{Sn}_x$ very attractive materials for CMOS-compatible optoelectronic devices based purely on group IV elements.

Our latest results demonstrate the formation of $\text{Si}_{1-x-y}\text{Ge}_x\text{Sn}_y$ nanowires by using Si-Ge single source precursors, which should enable the tailoring of bandgap and strain by compositional modulation in the solid solutions.

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[1] S. Barth, M. S. Seifner and S. Maldonado, *Chem. Mater.* **32**, 2703 (2020).

[2] M. S. Seifner, M. Sistani, F. Porrati, G. DiPrima, P. Pertl, M. Huth, A. Lugstein, S. Barth, *ACS Nano* **12**, 1236 (2018).

[3] M. S. Seifner, A. Dijkstra, J. Bernardi, A. Steiger-Thirsfeld, M. Sistani, A. Lugstein, J.E.M. Haverkort, S. Barth, *ACS Nano* **13**, 8047 (2019).

