# Abstract for HFML-FELIX user meeting 2025

# Sum- Frequency Generation Spectro-Microscopy using the FHI-FEL

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In this talk infrared-visible sum-frequency generation (SFG) spectro-microscopy using the FHI-FEL is introduced. This method combines benefits from second harmonic generation imaging such as local information on structural symmetry and benefits from sum-frequency generation spectroscopy such as details of the atomic structure and bonding via vibrational resonances.

We demonstrate an enhanced spatial resolution of a nineth of the IR-wavelength by imaging surface phonon polaritons in 4H-SiC nanostructures as a proof-of-concept [1]. In an extended work on a metasurface of SiC micropillars, spectro-microscopy is shown to measure the polariton dispersion simultaneously in momentum space by angle-dependent resonance imaging, and in real space by polariton interferometry [2]. At last, we demonstrate the feasibility of our method for spectroscopy using in-plane anisotropic wurtzite-type aluminum nitride as a model system [3] and show first data of our method's application to ferroelectrics.

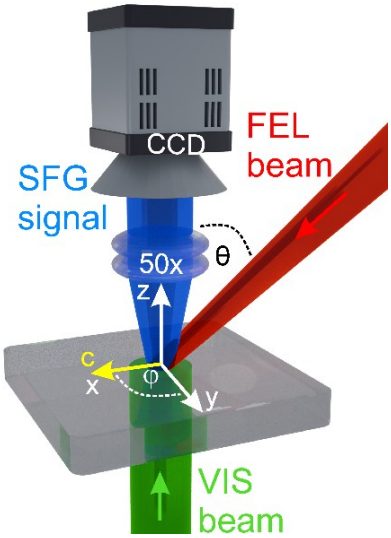


**Fig.1: Schematic Representation of the Experimental Setup**

## References

[1] R. Niemann, S. Wasserroth, G. Lu, S. Gewinner, M. de Pas, W. Schöllkopf, J.D.Caldwell, M.Wolf and A.Paarmann, "Long-wave infrared super-resolution wide-field microscopy using sum-frequency generation" *Appl. Phys. Lett.* **120**(13),131102, (**2022**).

[2] R. Niemann, N. S. Mueller, S. Wasserroth, G. Lu, M. Wolf, J. D. Caldwell and A. Paarmann,"Spectroscopic and Interferometric Sum-Frequency Imaging of Strongly Coupled Phonon Polaritons in SiC Metasurfaces" *Adv. Mat.* **36**(33), 2312507, (**2024**).

[3] D. S. Mader, R. Niemann, M. Wolf, S. F. Maehrlein and A.Paarmann," Sum-frequency generation spectro-microscopy in the reststrahlen band of wurtzite-type aluminum nitride" *J. Chem. Phys.* **161**, 094706 (**2024**)