Seminar of the IPQ

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"Strontium titanate as a novel Pockels material for quantum electro-optical applications"
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Abstract:

Quantum computers face many challenges towards upscaling the number of qubits and increasing their computational power. For superconducting qubits, this is the radio frequency (RF) -bottleneck between the qubit processor inside the cryostat and the room temperature control and readout electronics. And like for their classical counterparts, hope lies in replacing the RF-links by optical fibers, resulting in a hybrid situation where RF-qubits will be used for computation and optical qubits will serve for remote communication. However, electro-optical (EO) transducers that parametrically amplify RF-qubits directly to optical qubits with a unity efficiency have thus far remained elusive. Key to a unity efficiency are materials that feature low losses, strong nonlinearities and that allow to squeeze down the electro-magnetic field to smallest volumes. Current research focuses on devices based on opto-electro-mechanics or on lithium niobate devices - the classical workhorse of long-range optical communication. In this talk, we discuss high-k strontium titanate as a potential new material that features nonlinearities (Pockels coefficint of ~350pm/V) larger than any other materials, its unique challenges for EO-transduction and our progress on thin-film integration [1].

Quantum computers, especially those with superconducting qubits, are limited by the radio frequency (RF) bottleneck between cryogenic processors and room temperature electronics. Replacing RF-links with optical fibres could facilitate hybrid systems using RF-qubits for computation and optical qubits for communication. Achieving efficient electro-optical (EO) transduction requires materials with low losses, strong nonlinearities, and tight electromagnetic confinement. While lithium niobate is standard, this talk explores high-k strontium titanate as a promising alternative, boasting a high Pockels coefficient (~350 pm/V) [1]. In this talk we will discuss our recent progress on thin-film SrTiO3.

[1] Ulrich, A. et al. Engineering high pockels coefficients in thin-film strontium titanate for cryogenic quantum electro-optic applications. arXiv preprint (2025).

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CV:

Christian Haffner is a Principal Member of Technical Staff and the first to receive Imec’s tenure track. Imec is a world-leading research and innovation center in nanoelectronics and digital technologies. Christian’s tenure project investigates the fundamental limits of electro-optical devices for classical and quantum applications – or in simple words how small can a light switch be made. This research will eventually allow optical communication to happen at shorter and shorter distances even down to the chip-level. The quality of this research effort is confirmed by the competitive ERC starting grant being awarded to support his research. In 2019, he joined the 5-year Branco-Weiss Fellowship program. He did his Postdoc research on nano-scale opto-mechanical switches at NIST, Gaithersburg and ETH, Zurich. He earned his Ph.D. degree from ETH Zurich in 2018, which was recognized with the ETH Medal and Hans-Eggenberger Prize. His PhD research focused on using plasmonics as an active electro-optic device technology. He received his B.Sc. and M.Sc. degree in electrical engineering from the Karlsruhe Institute of Technology (Germany) in 2012 and in 2013, respectively. He was the top-ranked student in his master class. During his study, he received a scholarship from the German National Academic Foundation. His research has appeared in high-impact journals such as Nature, Nature Photonics, Science and Nano Letters. His publications have been highlighted by news outlets like the OSA’s Optics and Photonics News and the IEEE Spectrum.