Design and Implementation of a Temperature-Controlled Poling System for Advanced Nanomaterials

We are pleased to introduce an innovative and challenging research project within the Optical Nanomaterial Group.

This project focuses on the development of a temperature-controlled poling system to manipulate the domain orientation in $LiNbO_3$ (Lithium Niobate) thin films and $BaTiO_3$ (Barium Titanate) solgel. This enables the fabrication of Periodically Poled Lithium Niobate (PPLN), which allows the efficient generation of photons through second order nonlinear effects, such as second harmonic generation and spontaneous parametric down-conversion. The inverted domains of the crystal generate a grating which compensates for the momentum mismatch (Δk) between the different photon wavelengths. By precisely controlling the periodicity of the poling, constructive interference can be achieved with previously generated photons, resulting in enhanced photon generation efficiency.

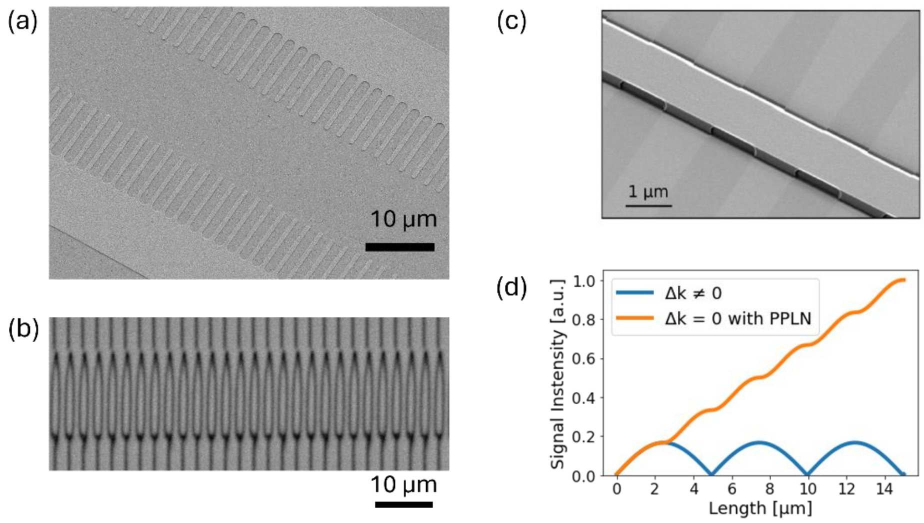

Figure 1 (a) Comb-like elctrodes used to apply a voltage difference in a periodic way. (b) Two-photon microscope image of PPLN. (c) Photonics waveguide etched into the PPLN region. (d) Second harmonic signal produced by unpoled and periodically poled lithium niobate.

The project offers the opportunity to work across multiple stages, from system development to device characterization. Specifically, it involves:

1. **Development of a Temperature-Controlled Poling System:**
   - The ability to apply temperature during the poling process reduces the periodic poling dimensions in LNOI (Lithium Niobate on Insulator) chips, allowing to achieve gratings with smaller periodicity[1]. Additionally, it enhances the polarization efficiency of polycrystalline $BaTiO_3$ solgel by enabling heating during the application of the electric field. You will implement the feature of temperature tuning in the poling setup.

2. **Electrical biasing and Optical characterization:**

    - Using the developed setup, you will apply high voltage bias pulses necessary for correct domain polarization and validate the poling process using a two-photon microscope.

Finally, a **critical experimental analysis** will be conducted to evaluate the temperature dependence of effective poling in the samples.

This project is designed not only to advance your technical expertise but also to foster critical thinking, creativity, and collaborative problem-solving skills. We look forward to the innovative solutions and insights you will bring to this exciting field of research.

For this project is preferred a background in physics.

If you are interested in this project and you want to join it for a semester project or a bachelor / master thesis please contact Dr. Virginia Falcone vfalcone@phys.ethz.ch, Eleni Prountzou eprountzou@student.ethz.ch, Alessandra Sabatti asabatti@student.ethz.ch.

[1] Q. Liu, et.al., *J. Appl. Phys.* **2020**; 128 (22): 224101. https://doi.org/10.1063/5.0029619