Berner Fachhochschule

Empa
Materials Science and Technology

Squeezing light at the nanoscale for 'seeing' single molecule vibrations: Fundamentals and setup automation

A Master's thesis opportunity at the Laboratory for Mechanics of Materials and Nanostructures (Empa) and the ALPS institute (BFH)

Project summary

Nanostructured matterials, so-called metamaterials, allows to focus, twist and bend electromagnetic radiation far below the diffraction limit of light to volumes <1 nm^3. In these nanoscale volumes common materials undergo unusual interactions with light amplifying their signal intensity by more that $>10^6$ times. Such signal enhancement now resolves even signals from individual molecules vibrating. The methodology here offers cost-effective solutions to a range of disciplines ranging from emerging diagnostics and bio-sensing to meteorology and astronomical detectors. This MSc thesis project, will utilise a reconfigurable optical microscope integrated with lasers and spectrometers to detect optical signal from nanoscale objects. Automation of the optical elements and data acquisition will offer a user friendly interface allowing the wide use of this powerful optical tool for a range applications. The focus here is to use intefaces as Labview, Matlab or Python to control individual optical components allowing advanced measurements at the nanoscale.

Further the optical microscope will be integrated with nanomechanical actuators to investigate mechanically induced modulation of the optical properties of nanoconstructs. This will require programming skills for precice control of nano-intendation stages to test the hardness of nanoscale optical devices. Their build quality and composition will be further assessed by scanning electron microscopy based analytics.

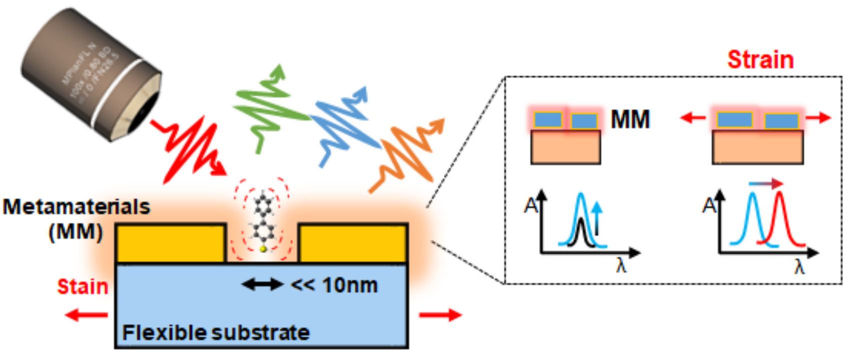

Figure: Vision of mechanically tunable metamaterial-based nanoscale devices for enhanced light detection. Left: Molecules encapsulated in metamaterial (MM) 'hotspots' for signal amplification. **Right:** Metamaterial antennas enhance the absorption cross-section (A) of matter (blue). Strain induced changes in MM shape and size result in fine tuning of their optical absorption wavelength.

Project workflow

- Development of control interface for a range of optical components (laser, lenses and polarisers)
- Assemble software interface for spectrometer read-out and data processing
- Validation of the optical measurements
- Application of the methodology to wafer-scale measurements
- Quality control by SEM-based material analytics

Main techniques involved and training

- Microscope development
- Labview/Matlab/Python programming
- Raman vibration Spectroscopy
- Spectroscopic Reflectometry
- Scanning electron microscopy

Skills required

- Programming/Automation undergraduate courses
- Mycrosystems remote control/programming
- Understanding/Knowledge of friendly user interfaces in LabView or/and Matlab and Python.

Timeline of the project

- 6 months

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Laboratories

https://www.empa.ch/web/s206
https://www.bfh.ch/de/forschung/forschungsbereiche/institut-applied-laser-photonics-surface-technologies/

Location

The project is a collaboration between laboratories in Thun (BE) and Biel (BE). The work will be mainly performed at the Laboratory for Mechanics of Materials and Nanostructures of Empa in Thun (BE).