Optical bio-sensing with GaInN heterostructures

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Basic ideas & final goal of the project

* Idea: GaInN quantum wells provide optical emission signal (photoluminescence, PL)
  → signal depends on band structure of GaInN
  → electric potential induces signal variations (i.e. adsorption of molecules on the surface)

* Goal: Develop intelligent portable biosensor based on this principle for use in medical environments

Surface functionalization

- Streptavidin-Biotin interaction is envisioned
  - This interaction is non-covalent, highly specific and resistant to changes in temperature and pH

  **Chemicals & Methods**

  ![Chemicals & Methods](image)

- Water soluble Biotin-PEG-Silane is used for biocompatibility
- Stamped structures on glass slide, pure GaN wafer or quantum well structure are successfully prepared (route 1)
- Stamped areas are characterized by fluorescence microscopy

  ![Stamped structure obtained via route 1 on (a) glass slide (b) GaN wafer (c) quantum well](image)

- Stamping of Ferritin-Biotin-Rhodamine complex on glass slide is confirmed by fluorescence microscopy (route 2)

  ![Stamped structure obtained via route 2 on glass slide](image)

Sensor structure

- QW parameters can be tuned to adjust photoluminescence and sensitivity
  → Simulations to find optimal sample parameters for sensing (simulations performed with nextnano)

  ![Comparison between simulations and experiments](image)

- Experimental verification of the influence of the cap layer thickness for background doping of \( \Delta n = 10^{-6} \) cm².
  General trend is confirmed

- Other simulations concerning parameters like QW thickness or Indium content were also performed

Spatially resolved µ-PL

- Functionalized areas of the sample are characterized using spatially resolved µ-PL

  ![Spatially resolved µ-PL](image)

- Laser is focused on the sample by a microscope objective.
- Sample is mounted on a x/y-stage and can be moved in steps of one µm.
- The QW is excited from the backside using a 405 nm laser to avoid absorption of the laser by the molecules on the surface of the sample.
- Evaluation of the PL intensity and center wavelength of the recorded spectra leads to a 2D map for the sample.
- By evaporating metal marks on the sample a defined position can be retrieved.

Conclusions and further steps

**Chemical:**
- Functionalization of GaN structure achieved → sensing of functionalized surface
- Optimized structures show increased sensitivity to Ferritin and Apoferritin.

**Sensor:**
- µ-PL setup for local & automated analysis of sensor constructed
- Functionalization of GaInN structure → sensing of functionalized surface
- Using gold marks to retrieve areas with functionalized GaInN surface

Acknowledgment:
This work was financially supported by the Baden-Württemberg Stiftung gGmbH within the project “Intelligente optoelektronische Biosensoren”.