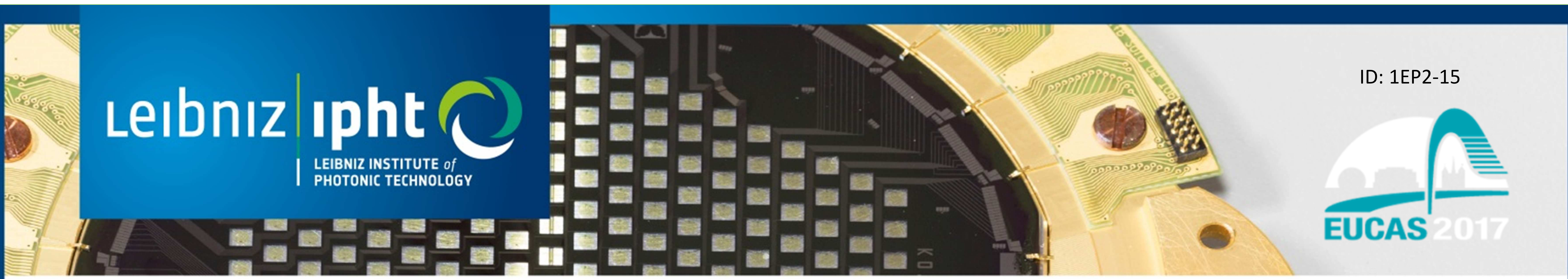

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Development of transition edge sensors for the application in real-time multispectral fluorescence-microscopy

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Introduction

In modern medical analysis, fluorescence microscopy has become an indispensable tool in imaging of biological tissue on a cellular level. A large variety of life processes can be visualized. Especially multispectral fluorescence microscopy (MFM) has drawn a lot of attention recently. This technique makes use of different types of probes that fluorescent at different wavelengths and thus is able to study the interaction of differently labeled organelles of a cell. State of the art approaches to record multispectral images are multiplexing in time for different wavelengths or laser scanning by illuminating pixels subsequently. Both techniques suffer from signal loss due to the multiplexing, which cannot be compensated by higher excitation intensities as these would damage fragile biological samples.

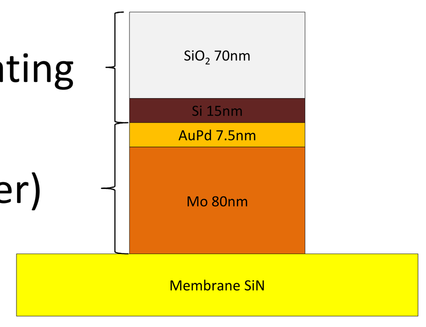
An approach to solve this problem could be the application of a cryocooled single photon detector which provides an appropriate energy resolution. We report on the development of membrane-supported transition edge sensors (TES) for this purpose.

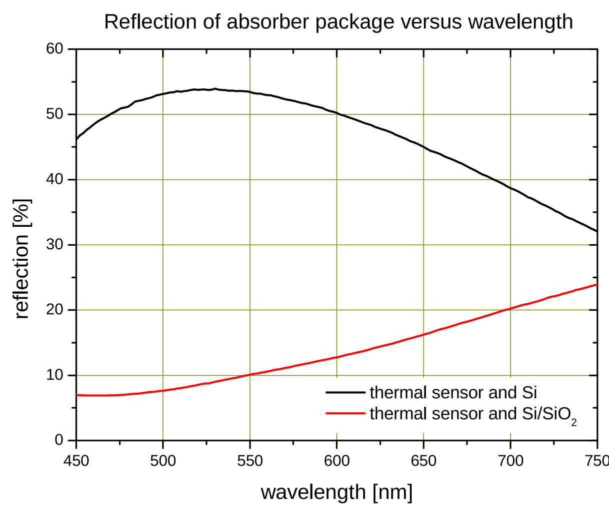
Sensor Parameters

- Wavelength range: 450…750 nm
- Working temperature: 400 mK
- Aspect ratio between length and width of membrane beams: 140:1 … 1400:1
- Detector area: 5 x 5 µm² … 100 x 100 µm²

Absorber Principle

Thermal sensor acts as absorbing metal and is combined with an antireflection coating:





Fabrication Technology

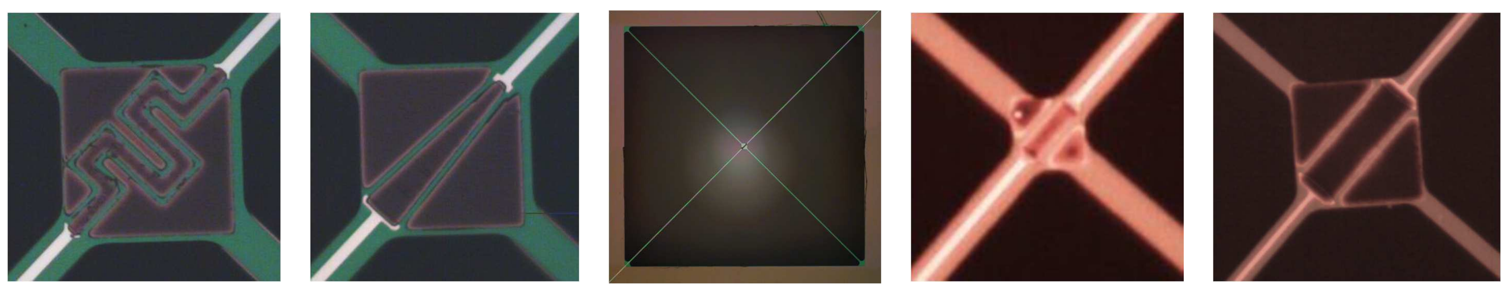
Membrane structuring

Beam width ≥ 5 µm

→ Mask aligner and photoresist mask
- Cycling (short etching time and longer cooling time) essential
- First working sensors produced

Beam width down to 1 µm

→ Waferstepper and Chrome hard mask
- Cr structuring via dry Cl etching process: successful for large dimension sizes, but problems with small structures after deep etching – Wiring (Nb) damaged
- Alternative possibility: wet etching or RIBE



Beam width 5 µm Area 30 x 30 µm² | Beam width 10 µm Area 50 x 50 µm² | Beam width 10 µm Length 1.4 mm | Beam width 5 µm Area 10 x 10 µm² | Beam width 5 µm Area 30 x 30 µm²

Wiring and Absorber package

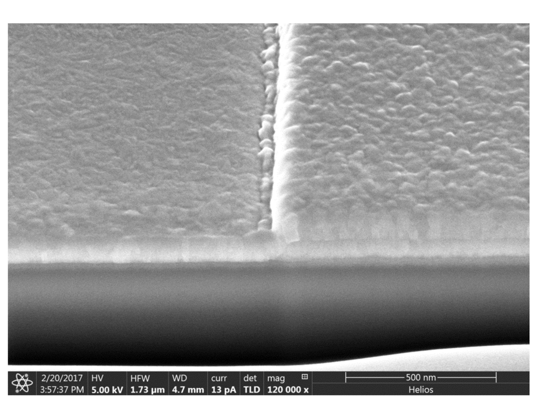
First layer: Wiring (90nm Nb)

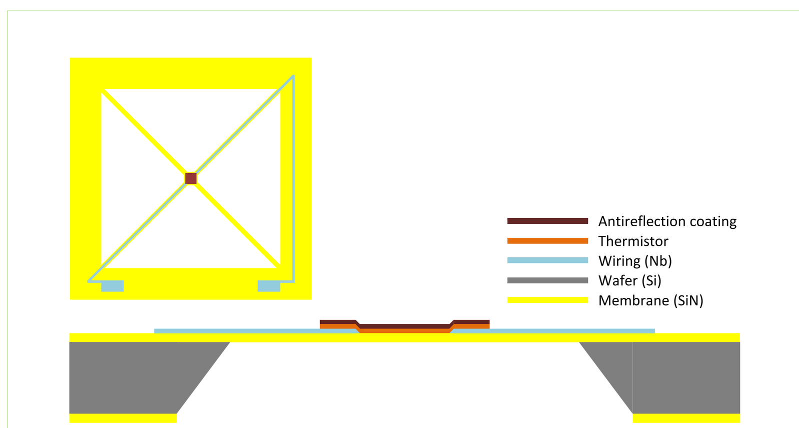
→ Structured via RIE etching process
- Sloped edges to allow for smooth connection to thermistor
- For width 1 µm or smaller problems with adhesion of resist

Second layer: Absorber package

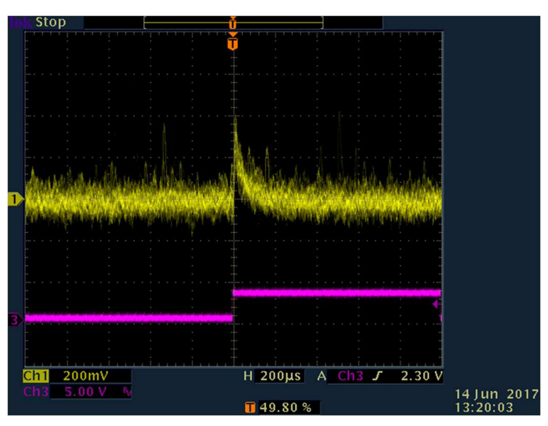
→ *in-situ* deposition of Mo, AuPd, Si (magnetron sputtering)

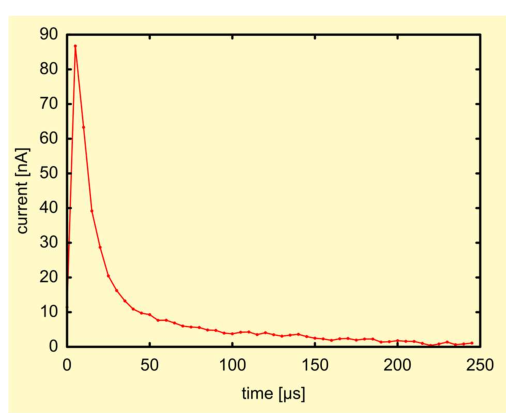
→ SiO_2 deposition (PECVD)

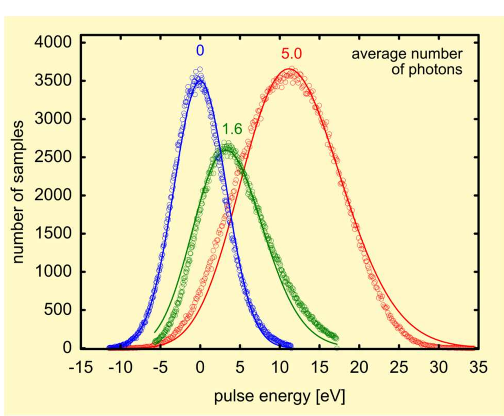




Results







Energy resolution: $\frac{\Delta E}{E}$ = 1.34 @ λ = 515 nm

Conclusions and Outlook

With our process we can fabricate mechanically stable membrane beams with widths down to 1 µm. The first functional TES detectors had a membrane beam width of 5 µm. The relative energy resolution $\Delta E/E$ was determined to be 1.34, which has to be increased further to meet the requirements of the intended application. It can be enhanced by reducing the heat capacity of the sensor and the thermal conductivity of the beams. To achieve this, we are still optimizing the fabrication technology to produce sensors with smaller structure sizes.

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