MEMPAD

Highly Stable Laser Technology for Photoacoustic Imaging

The MEMPAD collaborative research project aims to visualise biological tissue structures and fine vascular networks with high spatial resolution. It is investigating a photoacoustic imaging method using a novel array of optical microresonators. In the longer term, the technology is intended to enable compact, portable systems for cancer and vascular diagnostics. Sacher Lasertechnik is developing the highly stable, tunable laser source used to read out the microresonators optically.

Project at a glance

- **Collaborative project:** Array of Ellipsoidal Microresonators for High-Resolution Photoacoustic Detection
- **Acronym:** MEMPAD
- **Consortium coordinator:** Ruhr University Bochum, Chair of Laser Application Technology
- **Project partners:** Ruhr University Bochum, Cyberdyne and Sacher Lasertechnik
- **Sacher Lasertechnik subproject:** Highly Stable, Tunable Laser System for Detecting Photoacoustic Signals Using Microresonators
- **Funding reference:** 13N17990
- **Funding initiative:** Photonic and Quantum-Based Technologies for Medical Diagnostics and Therapy

Objectives and Approach

In photoacoustic imaging, light absorbed by a sample generates acoustic waves through brief heating. Analysis of these waves provides information about the spatial distribution of light-absorbing structures, such as blood vessels.

MEMPAD is investigating a new approach to detecting these acoustic waves: a densely arranged array of ellipsoidal microresonators serves as an optical ultrasound receiver. Incoming acoustic waves slightly deform the resonators, changing their optical resonances. A precision probe laser is intended to detect these changes. Photoacoustic images are subsequently reconstructed from the signals.

The consortium will integrate the microresonator arrays, a pulsed LED excitation source, the optical readout system and data processing into a shared laboratory demonstrator.

Sacher Lasertechnik's Contribution

Reliable readout of the microresonators places stringent requirements on the spectral purity and stability of the probe laser. Even small frequency fluctuations can impair detection of acoustically induced resonance changes.

Sacher Lasertechnik is therefore developing a narrow-linewidth continuous-wave laser operating around 780 nanometres. A tuning range of approximately two to three nanometres is intended to enable alignment with the microresonator resonances. The core of the design is a photonic integrated circuit, or PIC, serving as the external laser cavity. Two coupled high-Q ring resonators are intended to select and stabilise the laser wavelength through the Vernier effect.

Additional automatic active stabilisation is planned, preferably directly to the microresonator resonance. An automated start-up routine is intended to reach the appropriate operating point

without manual adjustment. For a compact and robust design, the laser chip and PIC will be precisely coupled and integrated into a butterfly package together with optical isolation and a fibre output.

Expected Results and Outlook

By the end of the subproject, a compact, fibre-coupled laser source is expected to be available for stable optical readout of the microresonator array. Its performance will be investigated jointly with the project partners and optimised for integration into the photoacoustic laboratory demonstrator. The complete system will be evaluated using standardised tissue and vascular phantoms and compared with conventional ultrasound detection.

MEMPAD thus establishes a foundation for new photonic ultrasound receivers and, in the longer term, portable point-of-care imaging systems. The PIC lasers, coupling methods and stabilisation algorithms developed also offer potential for further applications in optical sensing and precision metrology.