NeuroQ

Low-Noise Laser Technology for Quantum-Based Neural Interfaces

Controlling assistive devices through brain activity could offer new possibilities for people with impaired motor function. The NeuroQ collaborative research project is developing diamond-based quantum sensors for neural interfaces. Its objective is to demonstrate brain-controlled operation of an exoskeleton in patients. Project information in the official project atlas

Sacher Lasertechnik is developing a compact, high-power, ultra-low-noise laser system and the associated control electronics. Coating and assembly processes are also being developed to support integration of the optical components.

Project at a glance

- **Collaborative project:** Laser Threshold Magnetometers for Neural Communication Interfaces
- **Acronym:** NeuroQ
- **Project duration:** 1 December 2022 to 30 November 2027
- **Consortium coordinator:** Fraunhofer Institute for Applied Solid State Physics IAF
- **Sacher Lasertechnik subproject:** Low-Noise MECSEL Pump Laser with NV Diamonds
- **Funding:** German Federal Ministry of Research, Technology and Space (BMFTR), under the initiative “Lighthouse Projects in Quantum-Based Metrology to Address Societal Challenges”

Project duration, coordination and funding details are provided in the official project atlas.

Objectives and Approach

Neural interfaces, also known as brain-computer interfaces, acquire and process brain activity to derive control signals. NeuroQ investigates an approach based on diamonds containing nitrogen-vacancy centres, known as NV centres. These centres respond to magnetic fields, enabling optical measurement of magnetic signals.

The sensors are to be integrated into a compact, movable measurement module and subsequently tested in people for exoskeleton control. In the longer term, the approach is intended to enable multiple control commands, for example for moving several fingers. NeuroQ objectives and approach

Sacher Lasertechnik’s Contribution

Sensitive measurements require stable optical excitation of the NV centres. Fluctuations in laser power can obscure the measurement signals and limit achievable sensitivity. Sacher Lasertechnik is therefore developing a laser source at 532 nanometres that combines high output power with exceptionally low noise. The target output power is three to five watts in the green spectral range.

The proposed design comprises a master laser and several semiconductor amplifiers to pump a membrane external cavity surface-emitting laser, or MECSEL. This generates light at 1064 nanometres. Frequency doubling in a nonlinear crystal then produces the required green light at 532 nanometres.

FPGA-based control electronics are intended to provide precise electrical drive and stabilise critical operating parameters. Sacher Lasertechnik is also investigating different approaches to optical coupling of the NV diamonds. Anti-reflection coatings are intended to reduce unwanted reflections and improve optical excitation and fluorescence collection.

Expected Results and Outlook

By the end of the subproject, a compact laser demonstrator with associated electronics is expected to be available for testing within the consortium. In parallel, robot-assisted assembly processes are being developed to enable precise component positioning and prepare for reproducible manufacturing.

NeuroQ thus combines research into quantum-based neural interfaces with the development of key photonic components. Beyond this application, the planned low-noise laser source offers potential for further spectroscopic applications in research, medicine, environmental monitoring and industrial process control.