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Miniaturized Quantum Light Modules

The Ferdinand-Braun-Institut develops miniaturized quantum light modules for integration into mid-infrared (MIR) hyperspectral imaging and optical coherence tomography scanners. These quantum light modules use photon entanglement to transfer MIR information to the near-infrared (NIR), where it can easily be measured using conventional Si-based spectrometers.

High output power pump source

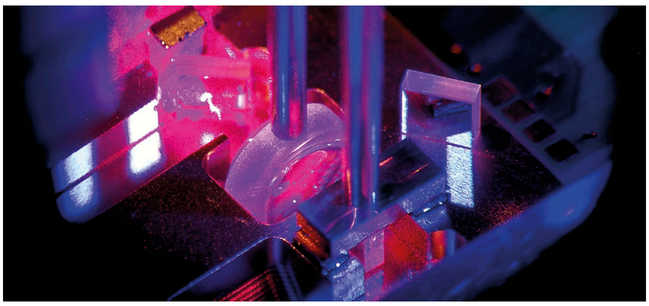
The modules produce quantum light via spontaneous parametric down conversion (SPDC). To start the SPDC process, a high power ($P \geq 1$ W) and coherent ($l_c \geq 1$ m) laser with a special emission wavelength is required. The FBH has developed single-mode DBR tapered diode lasers emitting at 660, 720, and 1170 nm for that purpose.

Entangled photons using SPDC

The intense pump light is focused on a PPKTP crystal, which produces entangled photons: in the MIR with a scanning range from 3,3 - 10 µm and in the NIR with a detection range from 780 - 930 nm using the SPDC process. The MIR and NIR photons are emitted collinearly with the residual pump light. The MIR light is split by a dichroic mirror, exits the module, and is directed to a sample, where it is partly backscattered. The NIR and the pump light remain in the module on a reference path.

Quantum interference and detection

The backscattered and the reference light travel back to the SPDC crystal. Here, they interfere like in a Michelson interferometer. Due to the entanglement, the information from the MIR is transferred to the NIR light via quantum interference. The NIR photons are then detected in a conventional spectrometer with a Si-based CCD sensor. The MIR photons remain 'undetected' in this process.



Microscope image of a high-power, single-mode 660 nm laser beam focused into the SPDC crystal in a quantum light module.

Quantum light module for optical coherence tomography (OCT) with 'undetected' photons – the world-wide smallest package for OCT in the MIR spectral range.

Applications

- non-destructive testing of ceramic materials
- identification of plastic materials for environmental analysis
- adaptable for early diagnostics of tumor cells

Profile

The Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik (FBH) researches electronic and optical components, modules and systems based on compound semiconductors. In the field of III-V electronics, it manufactures high-frequency devices and circuits for communications, power electronics, and sensor technology. Moreover, FBH develops light sources from the visible to the UV spectral range: high-power diode lasers, UV light sources, and hybrid laser systems. Applications range from medical technology, materials processing and sensors to optical communications in space and integrated quantum technology. In close cooperation with industry, its research results lead to cutting-edge products.

The institute is a member of the Leibniz Association and part of Research Fab Microelectronics Germany (FMD).