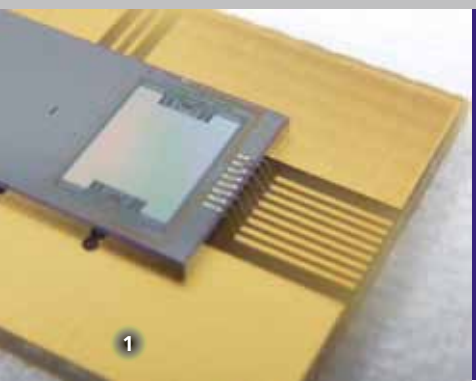
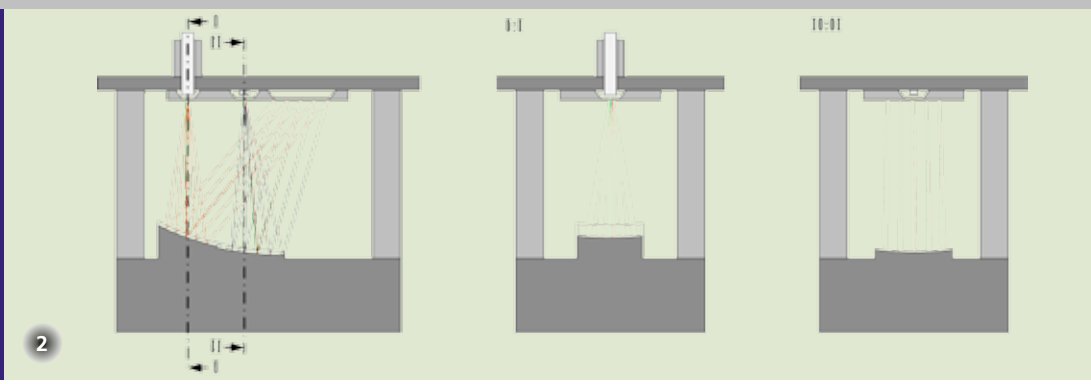
Fraunhofer
IPMS

FRAUNHOFER INSTITUTE FOR PHOTONIC MICROSYSTEMS IPMS





1 *MEMS with integrated diffraction grating, driving mechanism, position detection and optical slits.*
2 *Sectioning of the optical path of the miniaturized grating spectrometer.*

MINIATURIZED MEMS GRATING SPECTROMETER

Motivation

Spectrometers are well-established tools for the qualitative and quantitative analysis of various substances. Unlike many competing methods, they facilitate a non-contacting and non-destructive measurement by the use of electromagnetic radiation, whether the target is available in gaseous, liquid or solid state. The analysis of organic substances, frequently occurring in the fields of food chemistry, pharmacy as well as medical, environmental, security and housing technology is primary a field for the near-infrared region of the electromagnetic spectrum.

Grating spectrometers are a class of measurement devices best suited for the evaluation in the near infrared. Due to technology based reasons, applications that demand for a small system size and low power consumption, have not yet been covered. Spectroscopic tools as part of mobile devices for food inspectors, medical staff, environmental engineers and security personnel are part of addressed application scenarios just like spectroscopic sensors integrated in industrial equipment, transport systems and buildings.

Miniaturized grating spectrometers in upcoming mobile devices and stationary installations will facilitate an in situ data acquisition without additional sample taking and laboratory analysis. The transmission of chemometrical models and measurement results by the omnipresent available wireless interfaces supplements and complements the temporal efficiency and the gain in information.

Fraunhofer Institute for Photonic Microsystems IPMS

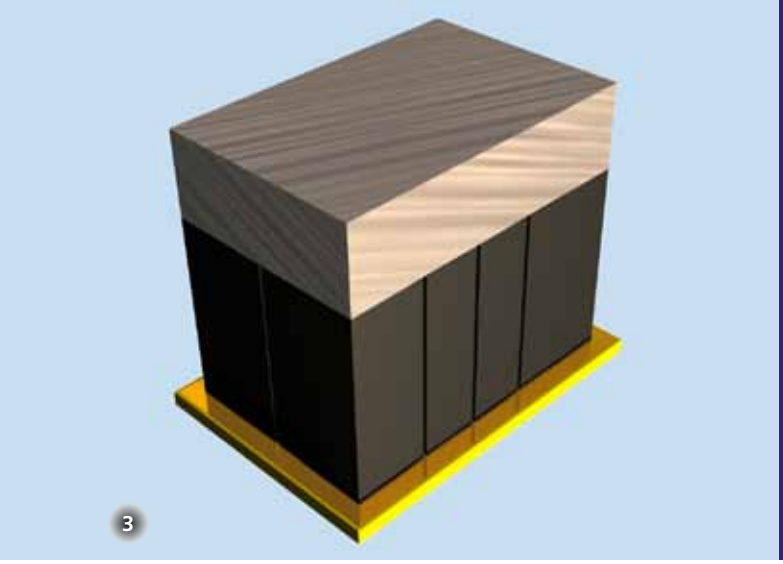
Maria-Reiche-Str. 2
01109 Dresden

Contact

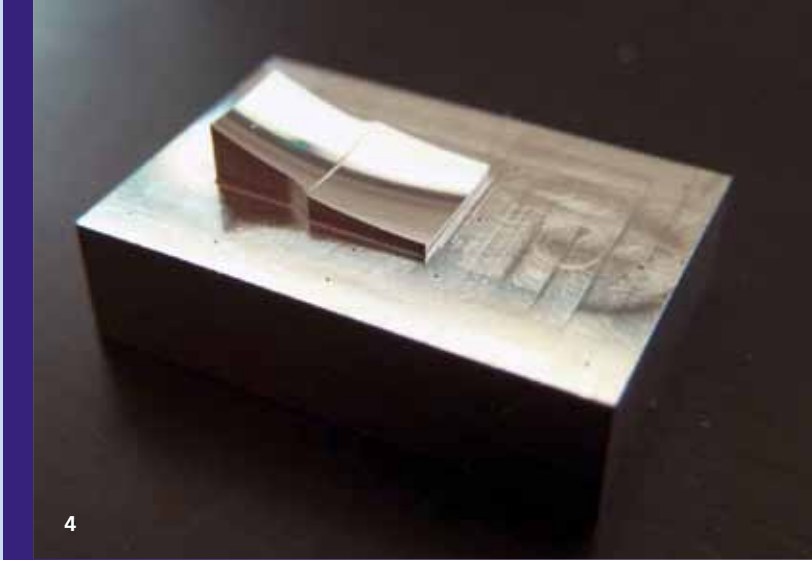
Dr. Michael Scholles
Phone +49 351 8823-201
michael.scholles@ipms.fraunhofer.de

Dr. Heinrich Grüger
Phone +49 351 8823-155
heinrich.grueger@ipms.fraunhofer.de

www.ipms.fraunhofer.de



3



4

Description

The miniaturized grating spectrometer developed at Fraunhofer Institute for Photonic Microsystems exhibits a volume of only 2.1 cm³ what is about 30% less than an ordinary sugar cube. Due to the small physical dimensions and a power consumption of only a few milliwatts, it is perfectly suited for the integration in mobile devices and the in situ measurement in industrial installations and buildings. With a measurement range between 950 nm and 1900 nm it aims mainly on applications in the fields of food chemistry, pharmacy, medical, environmental and security technologies as well as building services.

Functionality

Electromagnetic radiation that contains information of an investigated object is dispersed and measured regarding the spectral energy distribution by a spectrometer. Based on the resulting wavelength-intensity characteristic, the analysis of the target is performed by complex mathematical methods and chemometrical models. Grating spectrometers disperse radiation by diffraction and interference of radiation on a periodical structure. The presented spectrometer utilizes a time discrete measuring principle to acquire a spectrum only by the rotation of the integrated MEMS grating with a single highly sensitive detector.

Technology

The main component of the miniaturized grating spectrometer is a micro-electro-mechanical system (MEMS) developed at Fraunhofer IPMS that measures only (9.5 × 5.3 × 0.5) mm³. Beside the rotatory suspended grating and the associated driving mechanism, the device fabricated on monocrystalline silicon substrates features a piezoelectric position detection and two optical slits. The method of miniaturization by integration of functional elements as implemented in the MEMS device is consequently prosecuted in the other parts of the spectrometer. Each optical structural element contains more than one functional element and is fabricated by state of the art ultra-precision micromachining. All optical components can be produced for higher quantities and lower unit costs by micro molding technologies. Combined with fully automatic assembly at common standard micro assembly machines and the batch processing of MEMS technologies, even highest quantities can be produced at low costs.

Specification

- Measurement range: (950 … 1900) nm
- Resolution: 10 nm
- Dimensions: (16 × 17 × 12) mm³
- Volume: 2.1 cm³
- Weight: 17 g

Fields of Application

- Portable measurement devices for food industry and food chain management
- Mobile medical and pharmacological analysis tools
- Industrial measurement equipment for industrial production and processing facilities
- Early-warning and monitoring systems for security applications and facility management
- In situ measurement in the fields of environmental analysis and monitoring

3 *Rendered top-down view of the miniaturized grating spectrometer.*
4 *Microoptical part with two integrated mirrors.*