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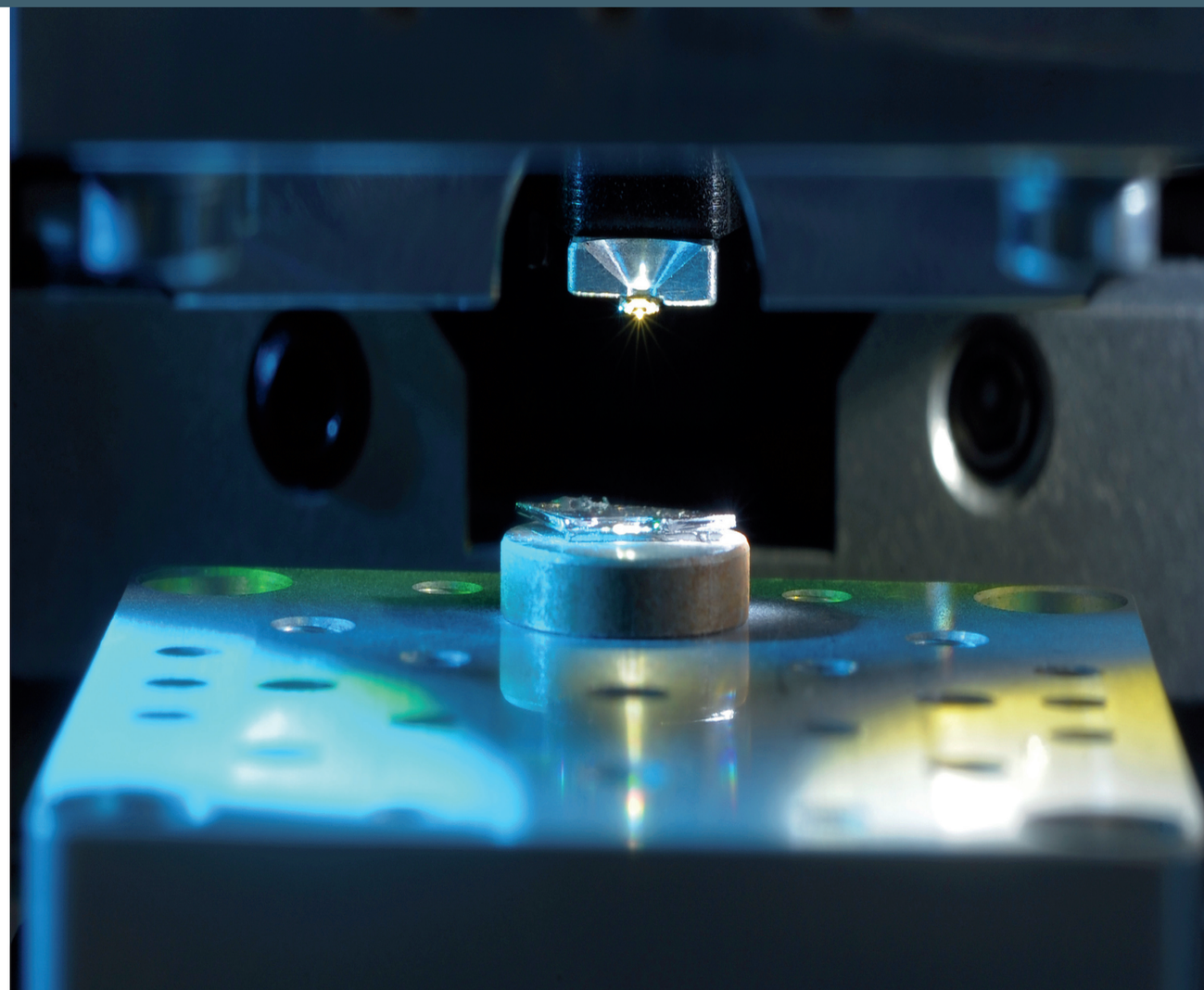
FRAUNHOFER INSTITUTE FOR LASER TECHNOLOGY ILT

MATERIALS ANALYSIS WITH NEAR-FIELD MICROSCOPY



Fraunhofer Institute for Laser Technology ILT

The Fraunhofer Institute for Laser Technology ILT is one of the most important development and contract research institutes in laser development and application worldwide. Its activities encompass a wide range of areas such as developing new laser beam sources and components, laser-based metrology, testing technology and industrial laser processes. This includes laser cutting, ablation, drilling, welding and soldering as well as surface treatment, micro processing and additive manufacturing. Furthermore, Fraunhofer ILT develops photonic components and beam sources for quantum technology.

Overall, Fraunhofer ILT is active in the fields of laser plant technology, digitalization, process monitoring and control, simulation and modeling, AI in laser technology and in the entire system technology. We offer feasibility studies, process qualification and laser integration in customized manufacturing lines. The institute focuses on research and development for industrial and societal challenges in the areas of health, safety, communication, production, mobility, energy and environment. Fraunhofer ILT is integrated into the Fraunhofer-Gesellschaft

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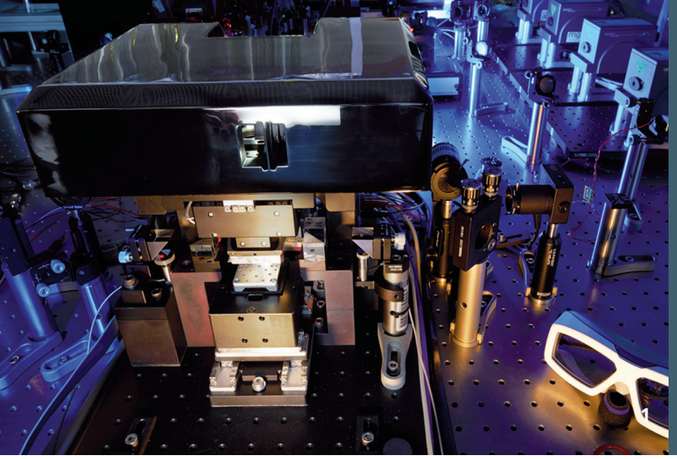
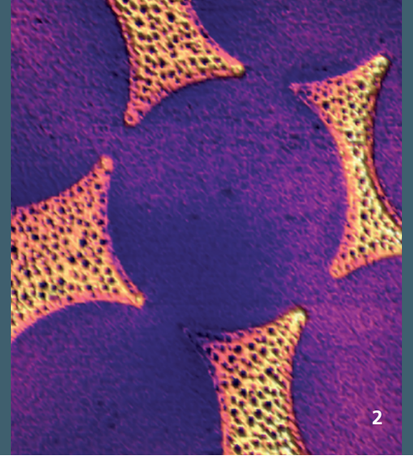
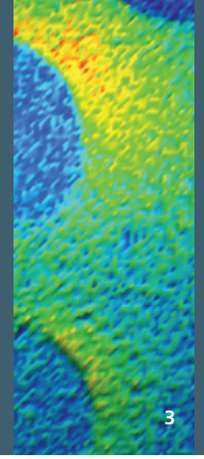
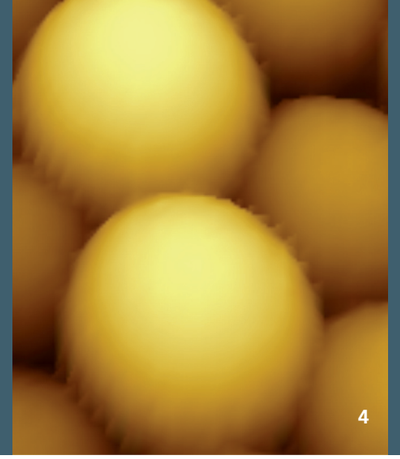
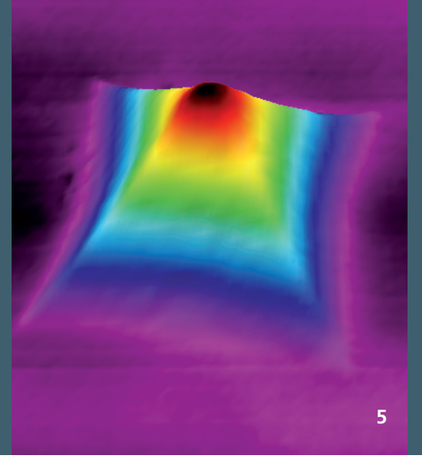
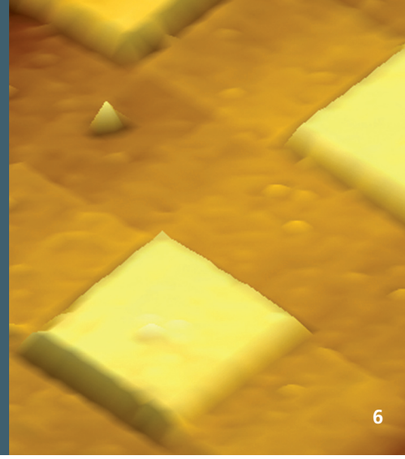
Fraunhofer Institute for Laser Technology ILT

Director
Prof. Constantin Häfner

Steinbachstraße 15
52074 Aachen, Germany
Telephone +49 241 8906-0
Fax +49 241 8906-121

info@ilt.fraunhofer.de
www.ilt.fraunhofer.de

MATERIALS ANALYSIS BEYOND THE DIFFRACTION LIMIT WITH NEAR-FIELD MICROSCOPY

Near-field microscopy is free from the constraints of the traditional diffraction limit and allows optical analysis of materials at a typical spatial resolution of 20 nm. The Fraunhofer Institute for Laser Technology ILT's new Application Center for Near-field Microscopy in Aachen carries out spectroscopic analysis at wavelengths of 5 µm to 15 µm for customers in the area of research and development.

Microscopy on a Nanometer-Scale

In traditional microscopy, diffraction always limits resolution capacity to around half of the wavelength of the input light. Conventional optical microscopes working with visible light can at best provide spatial resolutions of structures measuring several hundred nanometers. Such methods are therefore out of the question when undertaking nanometer-scale investigations in the infrared range, although this range is very well suited to spectral analysis of many materials, when taking a look, for example, at the excitation bands of molecules belonging to what is known as the fingerprint region. The technology behind near-field microscopy gets around these underlying limitations and allows diverse materials to be analyzed optically with a typical spatial resolution of 20 nm, regardless of the wavelength of the input laser light.

The basic element of this measuring technique is an atomic force microscope, which provides the topography of the sample by scanning its surface. A lens focuses additional laser light on the area of the probe tip. The light scattered back contains information on the sample's optical properties and the spatial resolution is now only limited by the geometry of the probe tip.

In contrast to other measuring techniques offering resolutions on a nanometer scale, such as tunnel microscopy or electron microscopy, near-field microscopy is sensitive not only to the chemical and structural, but also the electronic properties of the sample. Here it is even possible to discern structural elements present below the surface layer that remain hidden in purely topographic surveys.

Near-field microscopy combines the high local resolution of scanning with the depth of information that comes with spectroscopical analysis techniques.

Application Center for Near-field Microscopy

Fraunhofer ILT's new Application Center for Near-field Microscopy in Aachen offers its partners the possibility to analyze a broad spectrum of different materials, the key to which is tailoring the wavelength of the input light to the respective sample.

The Aachen location is well equipped for this purpose with a wide assortment of different laser systems including different CO and CO_2 lasers, quantum cascade lasers and even a tunable mid-infrared broad band laser that was developed by Fraunhofer ILT. The spectral range covered spans 5 µm to 15 µm.

In addition to performing measurement experiments, we also carry out computer simulations based on different near-field models. This enables us to link experiment data with samples underlying chemical, structural or electronic properties.

Additional techniques

Beside the near-field microscopy the Fraunhofer ILT offers different additional measurement and analysis techniques for the comprehensive categorization of materials:

- Optical microscopy
- Scanning electron microscopy
- Laser scanning microscopy
- Fourier transform infrared spectroscopy and microscopy
- Raman spectroscopy
- White light interferometry

Example Applications

It is possible to perform high-resolution analysis of a wealth of different materials using near-field microscopy, which is equally suitable for metals, semiconductors and plastics. Due to the very low level of mechanical interaction between the probe tip and the sample, soft materials such as biological cells can also be examined under the microscope without fear of damaging samples. This opens up a broad spectrum of materials and applications.

We are able to investigate for example:

- Tension and defects in crystal structures, including in particular semiconductor elements such as gallium nitride, silicon carbide or strontium titanate
- Measuring the secondary structure of proteins
- Absorption spectroscopy on polymer nanospheres, e.g. polystyrene, polymethyl methacrylate
- Analysis of nanocomposite materials, such as textile fibers with embedded nanoparticles
- Distribution of electron density within micro antennas
- Researching new kinds of meta-materials, such as super-lenses

We are at your disposal in the Application Center for Near-field Microscopy!

Contacts

Dr. Christoph Janzen
Telephone +49 241 8906-124
christoph.janzen@ilt.fraunhofer.de

1 Near-field microscope.
2 Fabricated gold nanostructures.
3 Electrically contacted $SrTiO_3$ layer system.
4 Polystyrene nanospheres.
5 Nanoindentation of a GaN surface.
6 Test pattern for system calibration.