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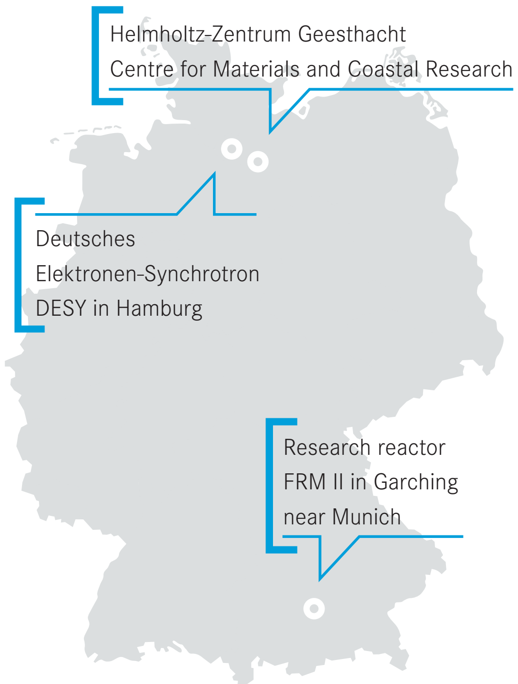

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

GEMS
German Engineering Materials Science Centre

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

Understanding Materials

German Engineering Materials Science Centre

INSTITUTE OF MATERIALS RESEARCH | STRUCTURAL RESEARCH ON NEW MATERIALS

Understanding Materials

German Engineering Materials Science Centre

The Helmholtz-Zentrum in Geesthacht has bundled its activities in the field of research with synchrotron radiation and neutrons at the “German Engineering Materials Science Centre” GEMS. GEMS is part of the Materials Physics Division of the Institute of Materials Research and offers a research platform which provides external users with unique research instruments for their materials research. The instruments at GEMS are available for the use of research scientists and engineers from universities, research institutes and industry with a strong focus on challenging in-situ experiments.

The synchrotron radiation instruments are operated at the storage ring PETRA III which is located at the Deutsches Elektronen Synchrotron DESY in Hamburg. The instruments using neutrons are located at the research reactor FRM II at the Heinz Maier-Leibnitz Zentrum (MLZ) in Garching near Munich. Based on this infrastructure GEMS offers combined synchrotron and neutron beamtimes.

GEMS
German Engineering Materials Science Centre

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Experimental hall at FRM II in Garching Photo:©Wenzel Schürmann, TUM

WHY ARE X-RAYS USED?

Synchrotron radiation is generated when charged particles such as electrons circulate in a storage ring (PETRA III at DESY in Hamburg). When electrons, accelerated to almost the speed of light, are directed around a curve by magnets, they always lose part of their energy by emitting a high intensity X-ray light beam. This beam is an ideal tool for scientists since the light from the accelerator is up to a million times more brilliant than from an X-ray tube in a doctor’s practice. Moreover, synchrotron radiation is almost as tightly bundled as a laser beam. As the wavelength of this radiation is considerably shorter than that of visible light, fine nanometer-sized structures, and even atoms, can be detected. Research scientists from almost every discipline use synchrotron light to closely scrutinize their samples: metals, polymers and protein molecules.

The instruments in Hamburg are IBL, HEMS and WINE, of which the last two are operated together with DESY.

WHY ARE NEUTRONS USED?

Scientists primarily rely on neutrons when experiments with X-rays are made difficult by the natural properties of specific materials. In many metals X-ray light can only penetrate to a limited extent, whereas neutrons are able to penetrate through an entire engine block. Neutrons, first discovered in 1932, are very small particles which, together with protons, form the nuclei of atoms. As neutrons are electrically neutral they can penetrate deep into a material. Using their experimental data, experts are able to deduce the detailed structure of the illuminated sample down to the level of atoms. On the basis of this knowledge, the properties of materials can be optimised and new materials can be tailored to requirements.

The instruments in Garching near Munich are REFSANS, SANS-1 and STRESS-SPEC, of which the last two are operated together with the Technical University Munich.

Solving materials problems with super microscopes

Synchrotron light in Hamburg

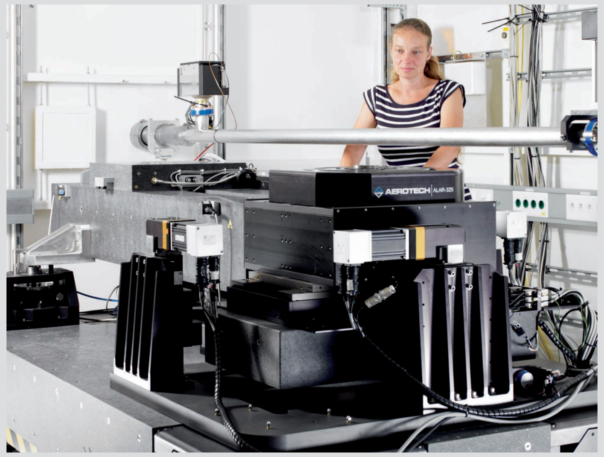
HEMS

©HZG/Peter Staron

Improving engines with HEMS (P07)

The High Energy Materials Science Beamline (HEMS) delivers X-rays with extremely high energies for penetrating deep into materials. This can be used for investigating, e.g. car engines. The industrial user needs to quantify internal stresses that have developed at specific locations inside a cylinder head during the manufacturing process. At such locations, fracture can occur during operation of the component. For materials for high-temperatur applications or additive manufacturing purposes, not only residual stresses are important, but also other microstructural characteristics like the content of different crystallographic phases, the texture, or strengthening nanoparticles. These features can be characterised at HEMS using various sample environments. Moreover, the high energy photons at HEMS can also be used for tomography of heavy materials.

IBL



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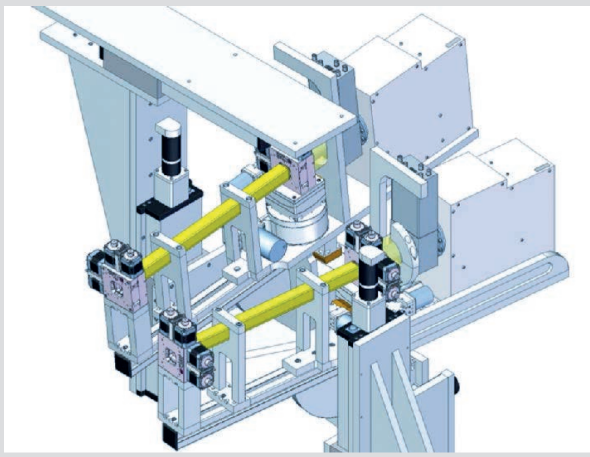
Imaging implants at IBL (P05)

The Imaging Beamline IBL takes particularly high resolution images which are very rich in detail. The resolution of the images goes right down to the nanometer level. However, the samples cannot be penetrated quite as deeply as with the HEMS-Beamline. For example, micro- and nanotomography images can show medical doctors in fine detail how implants have become connected to tissue.

WINE



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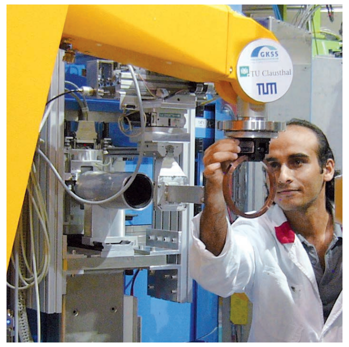
Exploring surface protecting layers with WINE (P61A)

The white beam engineering materials science beamline (WINE) offers unique experimental possibilities using energy-dispersive diffraction. Especially with the high-energy part of the spectrum, residual stresses can be analysed up to several 100 micrometre below the surface. This can be used, e.g. for controlling compressive stresses induced in a material by laser shock peening for increasing the lifetime of a component under service conditions. Energy-dispersive diffraction also allows to define a gauge volume that is fixed in space, making sure that the measured signal always comes from the desired volume inside the sample. Moreover, the high intensity of the white beam also enables high-speed radiography for imaging fast processes.

Neutrons for Materials Science

STRESS-SPEC



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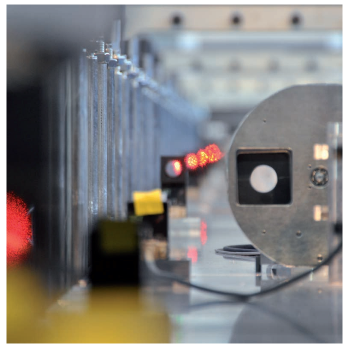
Increasing the safety of aircraft with STRESS-SPEC

The STRESS-SPEC diffractometer measures the mechanical stress and texture properties of materials – in particular in large steel components which cannot be penetrated by X-rays. Internal stresses occur in the material during production processes or as a result of deformation or heat treatment. These are decisive for the service life of a component. STRESS-SPEC is used to examine the turbine blades or crank-shafts of aircraft engines.

SANS-1



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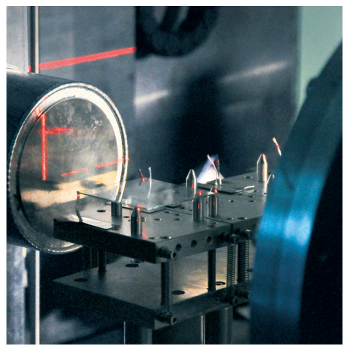
Improving materials with SANS-1

SANS-1 is dedicated to small-angle scattering which detects the size and density distribution of particles in materials. Investigations are carried out on large or thick components, e.g. made of steel to understand the connection of mechanical properties and strengthening particles included in such materials.

REFSANS



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Optimising implants with REFSANS

REFSANS is a reflectometer, specialised in the characterisation of interfaces. Neutrons are reflected from these surfaces as from a mirror. It can thus be determined how rough a surface is – important for example for the testing of new kinds of coating techniques for biomedical implants. Magnetic layer structures can also be examined effectively with this measuring facility. Nanomagnetic layers, which are intended for future use on hard drives, are therefore also investigated at REFSANS.

GEMS