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Centre for Materials and Coastal Research

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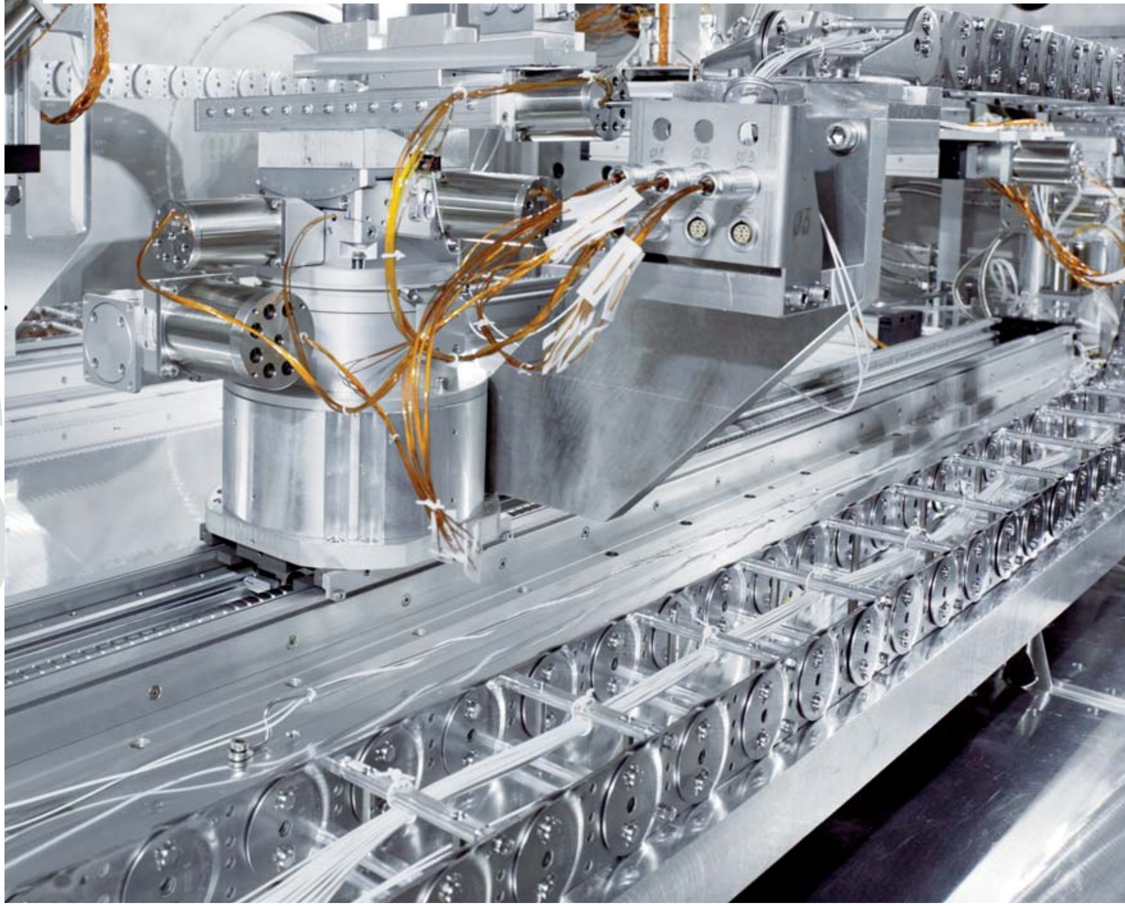
HELMHOLTZ-ZENTRUM GEESTHACHT

Understanding Materials
German Engineering Materials Science Centre



GEMS
German Engineering Materials Science Centre

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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 accelerator ring PETRA III which is located at the HZG outstation at the Deutsches Elektronen Synchrotron DESY in Hamburg. The instruments using neutrons are located at the research reactor FRM II at the HZG outstation in Garching near Munich. Based on this infrastructure GEMS offers combined synchrotron and neutron beamtimes.

GEMS
German Engineering Materials Science Centre

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

WHY IS X-RAY RADIATION 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 BioSAXS.

The latter two are operated together with DESY and EMBL, respectively.

WHY DOES SCIENCE USE NEUTRONS?

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.

The latter two are operated together with the Technical University Munich.

X-ray light in Hamburg

HEMS

→ Improving engines with HEMS

The High Energy Materials Science Beamline HEMS uses its particularly high energy X-rays to penetrate deep into materials. Research scientists investigate entire car engines with the HEMS instrument, for example. They search for internal stresses which have been developed inside the components during the manufacturing process. At these positions fractures can occur in operation. HEMS offers also the possibility of tomography. Research scientists rotate the work piece in the beam and, in doing so, create many images of the different projections which are used to reconstruct a 3 D image of the sample. This is similar to the way in which hospital computer tomography provides spatial images of the inside of a patient's body.

IBL

→ Imaging implants

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.

BioSAXS

→ Optimising the separation of CO_2 with BioSAXS

The Biological Small-Angle X-ray Scattering Beamline, BioSAXS, is specialised in the so-called "small-angle scattering technique". Research scientists send the X-ray beam through the sample and measure how strongly it fans out due to the structures in the sample. This method enables, for example, a reconstruction of how nanometer-sized structures are distributed in the sample – important for biological materials and metals but also for polymeric membranes, which are at some future to be used for the capture of carbon dioxide. Research scientists from Geesthacht operate this beamline together with the European Molecular Biology Laboratory (EMBL).

Solving materials problems with super microscopes

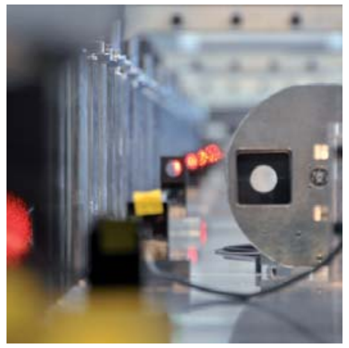
Neutrons for Materials Science

Stress-Spec

→ 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 crankshafts of aircraft engines.

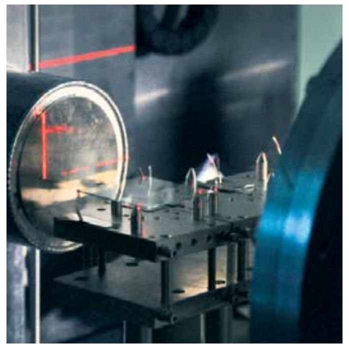
SANS-1



→ 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



→ 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.

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