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Press Release

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3D analysis of materials: German scientist receives lifetime achievement award from the American Society for Materials

Depending on the application for which it is being used, a material might need to be particularly strong, formable or stable at high temperatures. In order to be able to create materials exhibiting these and many other functional characteristics, scientists need to understand the interior structures of materials. Frank Mücklich, Professor of Functional Materials at Saarland University, has spent decades developing methods to do just that. In recognition of his lifetime achievement, Prof. Mücklich has been chosen to receive the Henry Clifton Sorby Award, the highest award bestowed by the American Society for Materials (ASM International) in the field of microscopic materials research. Mücklich (56) is only the fifth German to receive the award.

For materials with complex internal structures, researchers still do not precisely understand which substances or which mechanisms are responsible for controlling a desired material property. Experience gathered over many years can, of course, help them deduce how specific additives or processing steps may affect a material. 'In many cases, however, significant improvements often seem to arise by chance. With our analytical methods we are now able to visualize in three dimensions all of the changes in the internal structure of materials and to analyse them quantitatively,' explains Frank Mücklich, Professor of Functional Materials at Saarland University. This enables researchers to gain a better understanding of processes occurring during the production of a material, such as what happens inside the material when it undergoes deformation at a very specific temperature. The approach also helps to improve predictions as to how a specific property or combination of properties of a material might be obtained.

This is nicely illustrated by an example from the automotive industry. Lightweight engine blocks made from aluminium can be made significantly more rigid, by creating a specially formed microscopic network of silicon atoms within the aluminium. However, the resulting material has the disadvantage that it is very brittle, meaning that it breaks easily. Using the techniques of nanotomography, which they helped to develop, and atomic tomography, Mücklich and his team were able to show that embedding only a very few guest atoms (about one in ten thousand) into the crystal lattice of the host metal, produces a metal that still has the desired increased rigidity, but no longer exhibits the unwanted brittleness. ‘By incorporating such a small number of foreign atoms, we can effectively stop the growth of the silicon network. The silicon network is therefore reduced to isolated regions that can move relative to one another when the aluminium material is deformed, making the material more ductile. Materials of this type play a crucial role for the high-performance engines with high compression ratios used in premium-class vehicles,’ explains Mücklich.

Nanotomography produces images similar to those generated by the computed tomography (CT) technique used in medical examinations. ‘However, in nanotomography, the body under examination is not illuminated slice by slice, but undergoes nanoscale sectioning using a highly precise focused ion beam, and the resulting nano-slices are then scanned using an electron beam. The images recorded are then assembled in a computer to create a precise spatial representation of the material,’ explains the material scientist. In the Atom-Probe Tomography Lab, which was also set up by Prof. Mücklich in his department, the underlying methodology is slightly different. In this case, an extremely powerful electric field is used to eject individual atoms from a sample, which are then analysed and a computer-generated three-dimensional representation of the material is created.

‘The extremely high resolution that that we can achieve with tomography and the different phase-contrast techniques that we can use enable us to determine the chemical identity of the atoms in the material, and to visualize the crystal lattice structures in the material and the nanostructures that have been formed from them,’ explains Prof. Mücklich, who is also Director of the Steinbeis Materials Engineering Center Saarland (MECS) in Saarbrücken. If a material becomes brittle and fractures when subjected to high loads, it is often not enough just to examine the interior of the material at the micrometre scale. ‘Some of the properties of a material can only be explained when you zoom in by a factor of 1000, and examine the material’s structure at the nanoscale,’ says

Mücklich. When it came to analysing the material for the aluminium engine blocks even that wasn't enough and the research team needed to increase magnification by a further factor of 1000 to the atomic level. 'It's only by linking the different 2D and 3D imaging techniques across all size scales that we can begin to really understand the huge variety of material properties and how they relate to one another. Computer modelling is allowing us to optimize these properties and so develop new materials with customized combinations of properties,' says Mücklich.

Background to the Henry Clifton Sorby Award

The major US professional organization for materials science – the American Society for Materials (ASM International) has chosen to recognize Prof. Mücklich for his many years of ground-breaking research work. ASM International is therefore presenting Prof. Mücklich with this year's Henry Clifton Sorby Award in recognition of his lifetime achievement in the field. The Sorby Award has been presented annually since 1976 and is named after the legendary British scientist who pioneered the use of microscopy in materials research. Prof. Mücklich will receive the prestigious award on 25 July 2016 at the M&M (Microscopy & Microanalysis) 2016 Conference, which is being held in Columbus, Ohio. He is only the fifth German materials scientist to receive the US award. Prof. Mücklich will present the traditional Sorby Lecture, entitled 'From Correlative Microscopy to 3D Understanding of Material Microstructures'.

Background to Professor Frank Mücklich

Frank Mücklich studied physical metallurgy at the Freiberg Mining Academy and has headed the Department of Functional Materials at Saarland University since 1995. Since 2009, he has also held the position of Director of the Material Engineering Center Saarland (MECS) of the Steinbeis Foundation and is Chairman of the European School for Materials in Saarbrücken (EUSMAT). He is also Editor of the journal Practical Metallography – Preparation, Imaging and Analysis of Microstructures, which is published by Hanser. Frank Mücklich has received numerous awards, including the Georg Masing Prize, the Alfried Krupp Prize, the Georg Mitsche Prize and the Steinbeis Foundation Transfer Award. Mücklich was a member of the Board of the German Society for Materials Science (DGM) and he also heads the largest European conference on advanced materials and processes (Euromat), which is held every two years in Seville, Spain.

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