

# MATERIALS

A U S T R A L I A

## Capitalizing on Innovation

DMTC: Across the  
Materials Spectrum

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## Dr. Klaus-Dieter Liss – CMP Senior Research Fellow, The Bragg Institute, ANSTO



### Where were you born, and what prompted you to come to Australia?

I was born in a small town called Idar-Oberstein in Western Germany, but I lived there only for one year before moving to the South Bavarian area. A great part of my life I spent in France working at the Institut Laue Langevin and the European Synchrotron Radiation Facility in the beautiful French Alps. Fixed term contracts had me moving onto northern Germany for a short while, before I found an advertisement for the Bragg Institute which was in the process of building itself up, with the goal of becoming an international leading facility. I looked into that country at “the other end of the world” and realized that there was great potential for career development – but maybe one sentence in the job advertisement attracted me in particular to give it a try: “If you like a good life style in Sydney, feel free to apply...”

### Where are you working now and describe your job?

My current position is one of the two inaugural Senior Research Fellowships at ANSTO leading the project “Modern Diffraction Methods for the Investigation

of Thermo Mechanical Processes”. Thermo mechanical processes includes the shaping of metals, such as forging, rolling or severe plastic deformation like equal channel angular pressing. The goal is to bring the field of characterization techniques using neutron- and synchrotron diffraction together with the field of materials science. The point is really to develop and exploit new methods at the cutting edge of instrumentation, which can be hardware and also data analysis. I have a small team including students co-supervised with Australian universities. Sitting at the Bragg Institute, we are regular users of its instruments as we are at the big synchrotron radiation facilities in Europe and the USA. Typically, an experiment lasts a few days and data analysis takes us a few months. Starting initially with the in-situ investigation of phase transformations using neutrons or high-energy synchrotron X-rays, we met the milestone of publishing first in-situ and real-time investigations on the evolution of the microstructure in the bulk of a metal undergoing plastic deformation at 1100 °C, which is published these days as the cover story in *Advanced Engineering Materials*. The advantage of my job is, that I really can concentrate on science – and I do so, which is the only possibility to become world leading in the field. It is a great pleasure to work with the young people and built up success together in daily discussions and team work. But sometimes, I think, my real job is dragging hard disks containing terabytes of data from one computer to the other and crunching the numbers in order to publish a few critical seconds of an experiment.

### What inspired you to choose Materials Science and Engineering?

As a beamline scientist responsible at different neutron and synchrotron radiation facilities, I inevitably got in contact with materials scientists and engineers. First just as a user support, measurements were done, which, in a first approach, were very simple and straight forward from an experimental point of view, however, very important for that researcher to answer a peculiar question on his material. After a while, however, I realized that many don't understand diffraction as little as I

understood materials. The fear of asking stupid questions was overcome on each side and together, we saw the huge potential merging the two communities and strengths together. That inspired me to write down my project in this field which I do not regret.

### What is the best piece of advice you ever received?

I had many great teachers during my life. Maybe being a trained general physicist and mostly interested in fundamental science, the best piece relating to my actual position was given by one of my former supervisors, telling to me: “I am a trained physicist as well, working in materials science for twenty years. There is a lot of fundamental and applied physics going on in these materials, more than you can imagine right now. And it is a fantastic playground for a physicist. Give it a try!”

### What is your favourite thing about being involved in Materials?

Materials span a wide area. Condensed matter physics, engineering, geology, crystallography, minerals etc, while the findings range from very fundamental processes to very applied questions. It's a bit of a more realistic world, 'cause we do not just live in a model framework. A physicist drives an experiment under perfect sample conditions: a single crystal, a well defined temperature. However, real materials are often made out of polycrystals with many phases under various conditions. I find this a challenge to bridge the two worlds, and sometimes at the end, something becomes useful for a real application in a car or an aerospace engine.

### What is the most important characteristic a Certified Materials Professional must demonstrate in order to be viewed as a professional?

Competence and excellence in his field. As a professional, it is important that we can advise other people in the network on the knowledge we specialize in, and that others can rely on it. We actively have to spread our ideas, combine our strengths and get new people on board.

**What are the societal benefits of your field of study?**

The question is, what is a societal benefit! Starting from a research society, we have more capabilities in using the instruments at the OPAL reactor. For example, measurement capabilities for crystallographic texture have been set up through my project and are now available to the general neutron user community at OPAL. There is an educational benefit to the students and the collaborating universities and the acquisition of knowledge in our country – one of my former students applied his knowledge on in-situ neutron diffraction for optimizing a sintering process of stainless steel. We are part of an international network playing at the forefront in this field. The number of people wanting to use the newly developed methods is strongly increasing and lay the user basis for a potential future high-energy X-ray beamline at the Australian Synchrotron. The project aligns with our National Research Priorities, particularly in Frontier Technologies for Building and Transforming Australian Industries through Breakthrough Science, Frontier Technologies and Advanced Materials by an innovative development of the characterization methods which are of generic use for the research and technology society as well as the study of important materials, such as alloys for automotive and aerospace applications, light metals, alternative energies, nuclear reactor materials.

**Who has had the most influence on your thinking in the world of materials?**

If it comes down to the thinking on materials itself, maybe Dr. rer. nat. habil. Arno Bartels from the Hamburg University of Technology influenced me a lot. He was an excellent materials physicist with a broad and deep understanding ranging from the fundamental equations of physics to the rolling process of metals.

**What about your field of being a scientist do you think would surprise people the most?**

That I do not build bombs at ANSTO (nor anybody else), but that we can use the radiation coming from a reactor in order to study materials that everybody is familiar with in his daily life – investigating structures for airplanes, magnetism for computer hard disk drives, biology for better medicine to mention but a few.

**If you could only rescue one thing from your burning office or lab, what would it be?**

My bunch of lab logbooks and notes which I have acquired over the years. That is my hand-written knowledge everything is based on. All other things are replaceable and digital data is backed up at multiple locations. Although logbooks are now scanned electronically for backup, it is not the same thing...

**What music do you play most often in your lab or car?**

Although I like it, I don't play much music in the lab as I have to concentrate to be efficient. For the car, we live in the wonderful world of podcasts which allows me to listen to the latest science, computer and technology news – or just listen to the interview of one great person. I download them from different countries over the world. To relax, I like Jazz - Diana Krall; sometimes Bavarian music; sometimes critical music; sometimes aggressive; and classics.

**‘I had many great teachers during my life. Maybe being a trained general physicist and mostly interested in fundamental science, the best piece relating to my actual position was given by one of my former supervisors, telling to me: “I am a trained physicist as well, working in materials science for twenty years. There is a lot of fundamental and applied physics going on in these materials, more than you can imagine right now. And it is a fantastic playground for a physicist. Give it a try!’**

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## First-time in-situ insights into alloys

**New research has produced the first micro-scale, in-situ, real-time observations of detailed structural changes (dynamic recrystallisation) within alloys when placed under extremely high temperatures and stress (thermomechanics).**

The research provides unique information about materials used in the space and nuclear industries, which will aid the development of new materials and understanding of what they can ultimately endure.

The research, from ANSTO and the University of Wollongong, aimed at developing new methods of studying materials in-situ and in real-time using synchrotron technology at the Argonne National Laboratory in the United States.

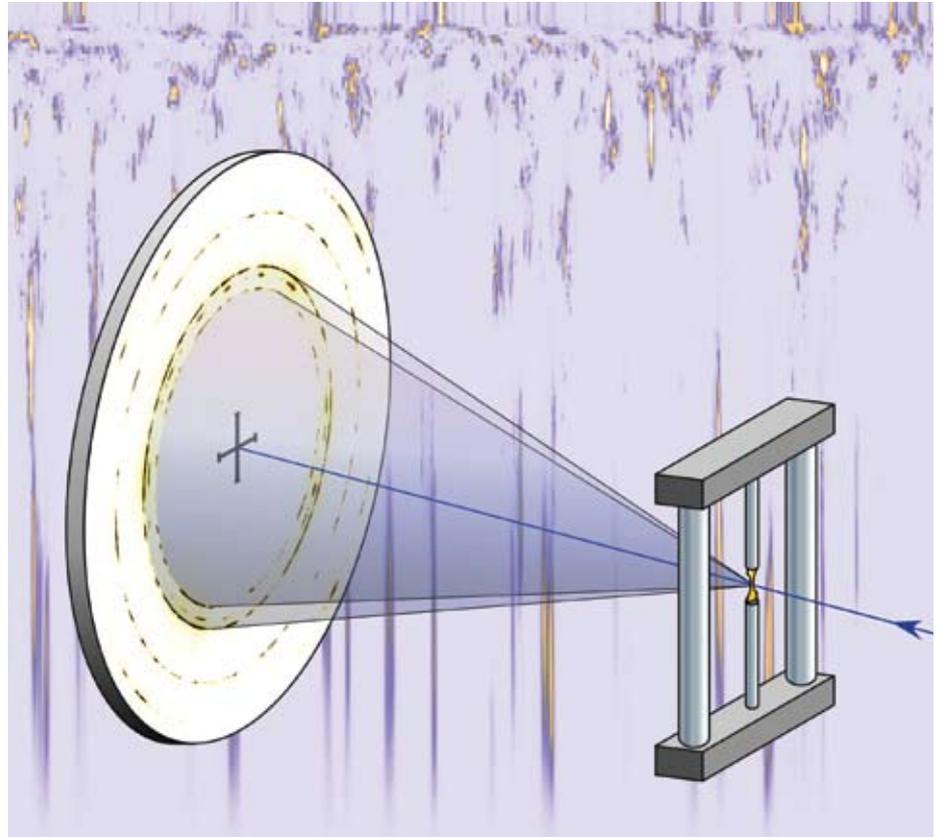
Presented at the Thermec' 2009 Conference in Berlin by ANSTO researcher Dr Klaus-Dieter Liss, the work was featured on the cover of the August edition of *Advanced Engineering Materials*.

"Common solids such as metals, ceramics and rocks are made out of micrometre-sized crystallites consolidated in a large block and the mechanical properties depend upon their size and orientation," explained Dr Liss.

"In a thermo-mechanical process, such as forging metal or occurring naturally in the Earth's crust, thermal effects that drive these structures towards the perfect crystal state compete with mechanical stress, breaking larger crystallites into smaller pieces – it is this process that is directly viewed for the first time in this research."

"The metal we studied was Zircaloy-4, which is used to hold fuel in ANSTO's OPAL nuclear research reactor core and meanwhile we have studied other materials for usage in space and jet aircraft. In the reactor core this material is exposed to extreme temperatures and radiation, so increasing our understanding of how it's affected at the atomic level is important for reactor maintenance and information for future generation developments and uses."

"Although these structural changes, scientifically known as dynamic recrystallisation, are commonly understood in science, predictions about how a specific



The figure shows the in-situ diffraction setup used at the Advanced Photon Source, USA. A fine synchrotron beam transmits the sample situated in a (heated) load frame and scatters into Debye-Scherrer cones. Large crystallites map onto spots onto the 2D detector rather than continuous rings. In the background, the intensity distribution of one selected reflection - here beta-Zr 110 - is plotted in colour scale as a function of azimuthal angle (horizontal axis) and time (vertical axis) revealing the different states during thermo-mechanical processing.

material will react are very difficult as they depend on a number of things such as chemistry, temperature, strain and data on thermo-mechanic history.

"This research focussed on developing a new method of observation, which successfully revealed all the microstructural kinetics, relevant statistics and crystal changes that occurred during the thermo-mechanic process, providing us with more detailed information about what is structurally taking place.

"This new research data is extremely important when studying how materials may react to stimuli, such as irradiation, over time and helps monitor their durability and reliability, as well as provide insights into new materials," he concluded.

Dr Liss is Materials Australia CMP and an inaugural ANSTO Senior Research Fellow working on Modern Diffraction Methods

Applied to Thermo-Mechanical Process in Materials Science.

**'The research provides unique information about materials used in the space and nuclear industries, which will aid the development of new materials and understanding of what they can ultimately endure.'**

For more information please contact ANSTO Media and Community Relations Manager, Sharon Kelly (02) 9717 9575