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Microscale Mechanical Behaviour Of Ultra-Fine-Grained Materials Processed By High-Pressure Torsion

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Abstract
A special networking seminar was given by Associate Professor Megumi Kawasaki from Hanyang University, South Korea. The seminar covered microscale mechanical behaviour of ultrafine- grained materials processed by high-pressure torsion, and was co-organised by the School of Mechanical, Materials and Mechatronic Engineering (MMME), University of Wollongong and Materials Australia NSW. The event was hosted on 20 September 2016 at a sponsored networking tea by MMME.

Keywords
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Source: Klaus-Dieter Liss

Associate Professor Megumi Kawasaki.

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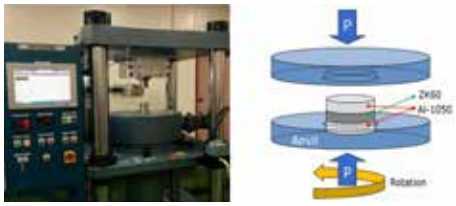
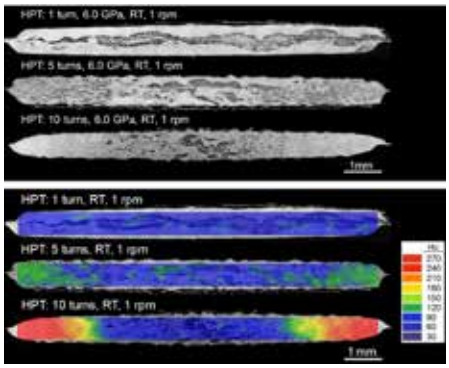


High-pressure torsion apparatus at Hanyang University (left) and schematic of processing (right). Specimens, here magnesium ZK60 and aluminium alloy Al-1050 were sandwiched and processed under pressure P = 6 GPa and up to 10 revolutions.

The processing of metals through the application of high-pressure torsion provides the potential for achieving exceptional grain refinement in bulk solids. Such a procedure can result in ultra-fine grains in bulk metals, which usually show superior mechanical and physical properties. In particular, the development of micro-mechanical behaviour has been reported after significant changes in microstructure upon processing and it is of great importance for obtaining practical future applications of these ultra-fine-grained metals.

The seminar not only flagged the importance for developing practical applications of these ultra-fine-grained metals but also demonstrated a basic understanding of high-pressure torsion processing. Special emphasis has been placed on demonstrating the essential microstructural changes of these materials with increasing straining by high-pressure torsion and the evolution of the micro-mechanical responses in these materials, by measuring the strain rate sensitivity and hardness by nano-indentation. Examples of refined, heterogeneous materials are shown in Figure 6 resulting in graduated materials, where microstructure and mechanical properties are emphasised in different regions.



Cross-section micrographs (top) and superimposed hardness maps (Hv) (bottom) of magnesium ZK60 and aluminium alloy Al-1050 sandwiches after high-pressure torsion (HPT, see left) at room temperature (RT). The figures demonstrate structural refinement and the evolution of graduated material.

Associate Professor Megumi Kawasaki is internationally renowned for her work on ultra-fine grained materials obtained by severe plastic deformation. She has spent a major part of her career at the University of Southern California where she is Adjunct Research Associate Professor at the Department of Aerospace and Mechanical Engineering. Furthermore, she holds a Visiting Associate Professor position at Osaka Prefecture University, Japan.

At Hanyang University, Megumi Kawasaki hosts a new high-pressure-torsion facility by which pressures up to 12 GPa can be applied (about twice as much as in existing facilities around the world). Apart from gradient materials and heterogeneous structures, she has successfully processed high-entropy alloys and titanium aluminide intermetallics. Even these brittle materials can be shear-strained by plastic strains of 50 and more.

Members of Materials Australia and students around the speaker at the networking event. L to R: Karl Maere, Azdiar Gazder, Yan Ma, Huijun Li, Megumi Kawasaki, Klaus-Dieter Liss, Martin Stewart, Zhiping Xiong.

The event was ideal for networking and stimulated exchange between the international visitor and other participants. The School of Mechanical, Materials and Mechatronic Engineering demonstrated some of their laboratory facilities on a personal interest basis: Professor Huijun Li discussed additive manufacturing by arc welding methods; Professor Rian Dippenaar referred to structural transformations with a demonstration by Dr Dominic Phelan of the attributes of high-temperature laser-scanning confocal microscopy. Dr Azdiar Gazder hosted a tour of the Electron Microscopy Centre and discussed in detail opportunities for the investigation of ultra-fine grained materials, which had already led to new collaborations at the time of writing.

Megumi Kawasaki and Dominic Phelan at the laser scanning confocal microscope with integrated differential thermal analysis, a device for in-situ high temperature studies.

Materials Australia New South Wales is seeking further local seminars by distinguished speakers as an opportunity for networking and exchange of experience between its members and their institutions. We would like to thank the School of Mechanical, Materials and Mechatronic Engineering for hosting this event, particularly Dr Hongtao Zhu and Professor Gursel Alici for organising the event.