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Workshop Report

WORKSHOP ON TRANSFORMATION TOUGHENING, LORNE, AUSTRALIA (15–19 April, 1985)

The workshop organised by the Zirconia group at CSIRO was host to many international participants. The largest contingents were from America and Australia but Japan, West Germany and the People's Republic of China were also strongly represented.

Of the four days devoted to the workshop, the first, after the official opening by Professor Polmear, was concerned with the crystallography, thermodynamics and nucleation of the transformation process in zirconia. Summaries of the state-of-knowledge in these areas were given by Professor A. H. Heuer in his usual lucid style, by Dr R. Cannon and Dr M. Rühle. Up-to-date information on the t' phase was given by Professor Heuer who, using electron micrographs to illustrate his ideas, showed it to be the stable non-transformable phase at room temperature. In this section Dr P. Kelly gave a discourse on the martensitic transformation process that was notable for both its clarity and quality.

The processing theme was developed by Dr F. F. Lange of the Rockwell International Science Centre who supplemented an earlier lecture on the distribution and source of flaws in engineering ceramics with pertinent information on the failure mechanism involved in the degradation of yttrium oxide-stabilised zirconium dioxide in the temperature range 150–400 °C. He showed convincing evidence of yttria removal from solid solution into discrete precipitates within adjacent porosity, the mechanism still being open to discussion. On the same topic, Dr Rühle suggested that mechanical constraint was necessary for the transformation to proceed.

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Phase diagrams were discussed in detail and it was a general conclusion of the meeting that great care was required to generate reproducible data, which could be affected by numerous variables, ranging from the powder source, to the disposition of the research worker.

As the meeting moved towards discussion of the means of attaining strength and toughness, it became apparent that two phenomena were becoming recognised as being of great importance, specifically, surface strengthening and a form of microplasticity caused by microtwinning in the relatively long range stress fields ahead of a crack tip. Dr D. Green gave an account of the methods available for the development of surface compressive stresses, concluding that removal of the stabilising oxide from the surface gives the greatest thickness (40–50 μm) of compressive layer. An elegant method developed at Utah was quoted, whereby slip-casting allowed the larger zirconium dioxide particles to be at a surface of a ceramic body; these larger particles are most likely to transform and the process thus gives a method for control of the thickness of the compressive surface layer.

Dr D. B. Marshall discussed perhaps the most significant work presented, the concept of a reversible $t \rightarrow m$ transformation. On loading, the surface of a test piece of Mg PSZ becomes rumpled on a scale equivalent to the grain size, the rumpling being removed on unloading, i.e. the process was reversible. Deformation strains of 0·17 % were achieved before 'microcracking' took place. On unloading, the surface became smooth apart from regions adjacent to the microcracks. X-ray diffraction data were also presented which indicated that the amount of monoclinic increased with the applied load and decreased as the load was removed. Dr Richard Hannick, the co-author of the original paper 'Ceramic steel', supported the hypothesis showing 'deformation bands', ~500 μm long, on the inner surface of a wire drawing die. In a later paper he showed again the similarity of the zirconia transformations to the martensitic transformation in steel.

Classic micrographs and experiments illustrating an isothermal transformation at 1340 °C in Mg PSZ were shown demonstrating that three stages of the precipitation process could be represented on a TTT (transformation/temperature/time) diagram, specific to the $MgO–ZrO_2$ ceramic.

The atmosphere of the conference was positive and enthusiastic and the participants foresaw a practical and increasingly useful place for zirconia ceramics in engineering materials. As a celebration of the ten years work of the Australian group, the meeting was a fitting accolade to the major contributions they have made over this period and was acknowledged as such by all those attending.

R. Stevens