INTERDISCIPLINARY CENTRE FOR ADVANCED MATERIALS SIMULATION

ICAMS Special Seminar

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Design and development of fracture property measurement techniques at the small-scale and its application to intermetallics

With emerging trends of miniaturization in every field, there is a need to pay increasing attention towards ductility and fracture at the small scale. Unlike strength which has been probed extensively in the micro and nano-scale regime, the effect of external size and material length scales on fracture behavior and deformability of materials remains largely unknown.
Fracture toughness tests of thin films, coatings and small-scale structures are being carried out using bulk testing geometries scaled down to the same-aspect ratios, but lack of ASTM standards brings about wide variations in the results reported by different groups, carried out using different geometries and testing systems.
A classic example is the TiAl microstructure. Due to different levels of hierarchy (colony size vs lamellar width vs individual phases), the fracture behavior will be very different when tested at the bulk scale and at the micro-scale. Crack growth is also expected to differ due to lamellar orientations while the crack path itself depends on the fracture toughness difference between the matrix and the interface. Such complexities in the microstructure call for a need to optimize the geometries to obtain stable crack growth and to study the difference in fracture behavior under different types of stresses that the material is exposed to.
As part of this goal, we first developed a new clamped beam geometry suitable to study stable fracture at the small scale. This was used to extract KIC and R-curve measurements in (Pt,Ni)Al bond coats, which are complex, heterogeneously structured coatings used in aero-engine blades for oxidation resistance. The geometry is easy to machine in the FIB as well as to load, both ex-situ and in-situ. This is further followed by a comparison of different test geometries using Si (with known KIC values) to choose the best one suitable for small scale systems. This combined experience in geometry as well as in testing intermetallics is now being applied to study fracture in PST-TiAl crystals along different lamellar orientations. Existing knowledge on deformation mechanisms of PST-TiAl as obtained from previous experiments will be shown and future work will be discussed.