Phase transformation in zirconia ceramics doped with ceria: A study by in-situ EBSD coupled with microcompression

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Abstract

It has recently been proposed that ceria-stabilised tetragonal zirconia (CSTZ) could be utilised to overcome the typical trade-off between strength and ductility observed in difficult-to-deform materials. This can be achieved thanks to the ability of these ceramics to undergo a stress-induced martensitic transformation (tetragonal-to-monoclinic, *t-m*) at quite moderate stresses. CSTZ exhibits transformation-induced plasticity (TRIP), analogous to shape-memory alloys, which is directly linked to the phase transformation. The phase transformation is found to be significantly influenced by both crystal orientation and grain distribution. By understanding the impact of these factors, it is possible to focus on the processing of ceramics with high transformability, optimising the use of their TRIP effect.

In this study, the tetragonal-to-monoclinic (t-m) phase transformation is investigated, with particular emphasis on the role of microstructure in driving and influencing this transformation. The investigation focuses on both the crystallographic and mechanical factors that govern the initiation and subsequent propagation of the phase transformation. To explore these aspects, single- and oligocrystalline zirconia micropillars containing 12 mol% ceria (CeO2) were fabricated by focused ion beam (FIB) micromachining out of bulk material. Incorporating this amount of ceria ensures the stability of the tetragonal phase, whilst still allowing for phase transformation to occur when a critical stress is reached. Subsequently, *in-situ* electron backscatter diffraction (EBSD) coupled with microcompression testing was performed, to provide information concerning the crystallographic orientation and phase change. Finite-element method (FEM) analysis was performed to better understand the impact of the boundary conditions on the localization of the transformation.

The results demonstrate that in single-crystalline micropillars, stress concentrations arising

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from boundary conditions play a key role in determining the onset of phase transformation. In oligocrystalline micropillars, the crystalline orientation and arrangement of grains as well as the presence of defects significantly influence both the initiation and progression of the transformation. This approach facilitates a deeper analysis of the interplay between microstructural features and the evolution of the t-m phase transformation under mechanical loading.