Shape memory zirconia-based ceramic micropillars studied by in situ Laue microdiffraction

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Thanks to a stress-induced martensitic phase transformation from tetragonal to monoclinic (t-m), zirconia-based ceramics can exhibit plasticity at room temperature, overcoming the limited ductility and toughness of ceramics. This is a consequence of the traditional trade-off between the strength and ductility of hard-to-deform materials. More recently, it was shown that zirconia-based ceramics stabilised by ceria (CSTZ) undergo transformation at lower stresses and prior to crack initiation [1] than yttria-stabilised tetragonal zirconia [2-4], leading to greater ductility. This transformation-induced plasticity (TRIP) deformation process is analogous to the martensitic transformation in metallic shape-memory alloys (SMAs). As with SMAs, a transformed CSTZ ceramic can transform back from the monoclinic to the tetragonal phase when heated above a critical temperature. Nevertheless, predicting and optimising the macroscopic ductility and phase-memory behaviour of bulk ceramics requires a multiscale approach to understand (1) the transformation at the grain level and (2) its propagation across grain boundaries.

Here, we present in situ Laue microdiffraction studies of the shape memory behaviour of CSTZ micropillars. The tetragonal-monoclinic phase transformation was examined by in situ microcompression, while the reverse transformation was monitored during annealing. The critical stress for the t-m transformation was found to depend on the crystal orientation of the micropillar, with the highest stress occurring in (001)-oriented pillars [5]. This critical stress decreases with the number of compression-heating cycles, likely due to the nucleation of defects such as dislocations and antiphase boundaries. The reverse transformation occurs at a critical temperature on the order of 350 °C, which seems to also be dependent on the number of transformation cycles.

References

[1] J. Chevalier et al., J. Am. Cer. Soc. 103, 1482 (2020)
[2] J. Chevalier et al., J. Am. Cer. Soc. 92, 1901 (2009)
[3] X. Zeng et al., Acta Mater. 116, 124 (2016)
[4] N. Zhang et al., Acta Mater. 120, 337 (2016)
[5] M.D. de Magalhães et al., J. Eur. Cer. Soc. 45, 116794 (2025)