Strains, stresses and microcracks in pure zirconia polycrystals

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Abstract

In pure dense zirconia-based materials, cooling induces a martensitic phase transition associated with a large variation of the ZrO2 molecular volume and anisotropic thermal expansion, both leading to very high level of internal stresses and the formation of large multiscale microcrack networks. We investigate the relationships between the main crystal planes or directions and the orientation of the microcracks using specimens that have undergone only one thermal cooling from the liquid state to room temperature. Two crack orientations have been identified. The first one occurs on the {001}m planes of monoclinic crystals. The second one is on the {110}c planes of the parent cubic phase. We propose to explain these observations through the calculation of stresses and strains induced by phase transitions all along the cooling process, using a micromechanical approach. The experimental observations of crack orientations are in good agreement with the strain model based on a phenomenological approach of the martensitic transformation. Accordingly, strain accommodation mechanisms during this transition seem to be a decisive factor in crack or twin boundary formations between individual monoclinic crystals.

Keywords: Pure zirconia, martensitic phase transformation, micromechanical modelling, microcracks, EBSD

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