SPS sintered YTZP-MWCNT nanocomposites with an outstanding crack and ageing resistance

Garmendia N.[a], Grandjean S.[b], Chevalier J.[b], Diaz L.A.[c], Torrecillas R.[c] and Obieta I.[a]
[a] TECNALIA, San Sebastian, E20009, Gipuzkoa, Spain.
Ciber BBN, San Sebastian, Spain.
[b] MATEIS UMR CNRS 5510, INSA-Lyon, Villeurbanne Cedex, 69621, France.
[c] Nanomaterials and Nanotechnology Research Center (CINN), Principado de Asturias – Consejo Superior de Investigaciones Científicas (CSIC) – Universidad de Oviedo (UO), Parque Tecnológico de Asturias, Llanera, Asturias, Spain

nere.garmendia@tecnalia.com

Yttria Stabilized Zirconia (YTZP) ceramics are widely used in biomedical applications such as orthopedic and dental implants. The biocompatible YTZP shows high crack resistance for a ceramic due to a phase transformation reinforcement mechanism [1-2]. However, the major drawback of YTZP is its lack of stability: zirconia is prone to ageing especially (but not only) under humid atmosphere. Ageing is referred to a slow surface transformation of the zirconia from its high temperature structure (tetragonal structure), obtained by the stabilization of the ceramic with yttria, into the stable monoclinic phase in the presence of water or water vapor. This transformation induces surface roughening, microcracking and, for the most severe cases, failure and loss of functionality. The most dramatic case of ageing was reported at the beginning of 2002 for zirconia hip joints heads, when several hundreds of implants failed within a short period [3]. There have been several attempts in the recent literature to increase the ageing resistance of YTZP. However, increasing the ageing resistance of YTZP led so far to a decrease of toughness and crack resistance. This is due to the fact that to avoid the ageing it is necessary to reduce the transformability of the zirconia, reaching a more stable tetragonal phase. But this will also imply less transformability under stress, which results in lower mechanical strength. On the one hand, the reduction of the zirconia grain size to a submicrometric or nanometric level, limits the phase transformation and, therefore, ageing is delayed [4-5]. But, on the other hand, the fracture toughness is reduced, because the transformation toughening mechanism is lost.

In this work the addition of a small volume fraction of multiwall carbon nanotubes (MWCNT) in a polycrystalline, nano-structured YTZP, sintered by Spark plasma Sintering (SPS) leads to a material exhibiting a balance between ageing and crack resistance never reached before.

References

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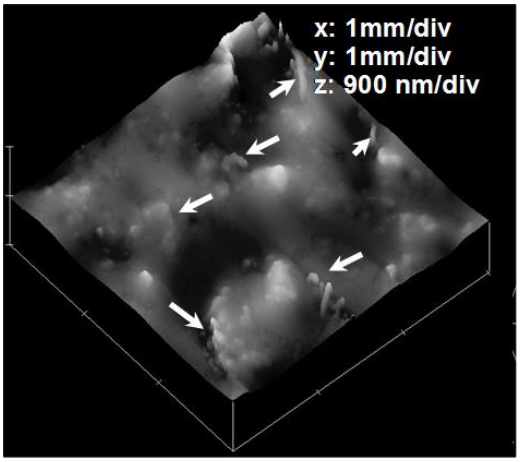
Figures



AFM image of an YTZP-MWCNT sample sintered by SPS showing the carbon nanotube pull-out on the fracture surface