Exceptional contact damage tolerance of alumina-based multilayer ceramics with tailored microstructures

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ABSTRACT

The "bio-inspired" concept of designing ceramics in a layered architecture has proven to be an effective way for overcoming the lack of damage tolerance and enhancing the mechanical properties of ceramics [1]. An important property required for many modern engineering applications is the resistance to contact damage. This work demonstrates the effect of microstructure tailoring in a layered architecture to increase the contact damage tolerance of alumina-based ceramics. The multilayer system with textured alumina layers under internal compressive residual stresses embedded between alumina-zirconia layers was investigated under Hertzian contact loading and compared to the corresponding monolithic reference materials. Critical forces for crack initiation under spherical contact were detected through an acoustic emission system. Damage was assessed by combining cross-section polishing and ion-slicing techniques. It was found that a textured microstructure can accommodate the damage below the surface by shear-driven, quasi-plastic deformation instead of the classical Hertzian cone cracking observed in equiaxed alumina. In the multilayer design a combination of both mechanisms, Hertzian cone cracking on the top surface layer and quasi-plastic deformation within the embedded textured layer, was explored. The internal compressive textured layer deflected cone cracks propagating from the surface and restricted their growth even at higher applied loads. These findings demonstrate the potential of embedding textured layers as a strategy to enhance the contact damage tolerance in alumina ceramics [2].

[1] R. Bermejo, J. Eur. Ceram. Soc. 37 (2017) 3823–3839.
[2] J. Schlacher, A. Jabr, A.-K. Hofer, R. Bermejo, J. Am. Ceram. Soc. (2022) 1–13.