Bioinspired Design of Ceramic Dental Crowns

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Abstract

This talks combines experiments, simulations and analytical modeling that are inspired by the stress reductions associated with the functionally graded structures of the dentin-enamel junctions (DEJs) in natural teeth. Unlike conventional crown structures in which ceramic crowns are bonded to the bottom layer with an adhesive layer, real teeth do not have a distinct adhesive layer between the enamel and the dentin layers. Instead, there is a graded transition from enamel to dentin within a 10 to 100 mm thick regime that is called the Dentin Enamel Junction (DEJ). In this work, a microscale, bioinspired functionally graded structure is used to bond the top ceramic layer (zirconia) to a dentin-like ceramic-filled polymer substrate. The bioinspired functionally graded material (FGM) is shown to exhibit higher critical loads over a wide range of loading rates. Finite element modeling was also used to explore the effects of thickness and architecture on the contact-induced stresses that are induced in bio-inspired dental multilayers. A layered nanocomposite structure was then fabricated by the sequential rolling of micro-scale nanocomposite materials with local moduli that increase from the side near the soft dentin-like polymer composite foundation to the side near the top ceramic layer. The implications of the results are then discussed for the design of bioinspired dental multilayers. The measured critical loads are predicted using a rate dependent slow crack growth (RDEASCG) model.

Keywords: Fracture Toughness, Stress Intensity factors, dentin, enamel, functionally graded adhesive