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Experimental and numerical study of the particle size and volume fraction effects on thermal residual stresses and fracture of metal-ceramic composites

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This lecture presents an experimental and numerical study of the relationship '*microstructure - residual stress - fracture'* in hot pressed metal-ceramic bulk composites Cr/Al_2O_3 and $NiAl/Al_2O_3$, which was motivated by their potential use in the automotive industry. Series of composites containing 0, 30, 60, 90, 100 vol. % of alumina were produced by pressure sintering using two different sizes of Cr and NiAl powders (5 μm and 45 μm). For comparative purposes a series of interpenetrating phase composites $AlSi12/Al_2O_3$ was also produced and investigated. By applying two processing techniques (sintering and infiltration), three different metal/intermetallic matrices (Cr, NiAl, AlSi12) and two particle sizes(5 μm and 45 μm), a wide spectrum of microstructures was obtained enabling investigation of the effect of microstructure on thermal residual stresses, bending strength and fracture toughness. Thermal residual stresses were measured by: neutron diffraction, X-ray diffraction, Raman and photoluminescence piezospectroscopy. All four experimental methods have confirmed existence of anomalous tensile residual stresses in the ceramic phase of Cr/Al_2O_3 made with the fine chromium powder, irrespective of the volume fraction. This effect is traced back to a strongly irregular microstructure. In quantitative terms it is interpreted by means of micro-CT FEM simulations. The experimental and simulation results are discussed and conclusions are drawn as to the *microstructure - residual stress – fracture* relationship.