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Thermal barrier coating systems are exposed to temperature changes during service which lead to stresses in a composite system like bi- or multilayer system due to constraining effect of a much thicker substrate. The internal stresses promote processes like fatigue or rumpling which lead to spalling or reduced service time.

However, obtaining information about internal stresses especially in commonly used bond coat systems is complicated by several factors like gradients in composition and mechanical properties. In this work two novel methods to measure residual stresses are demonstrated on a ~100 µm thick NiAl based bond coat on a PWA 1484 substrate.

The first method is a focused ion beam (FIB) and digital image correlation (DIC) based method which allows to measure stresses at micron length scale and so reducing the influence of gradients in the material's properties. Two trenches ~5 µm apart and ~15 µm long are milled by a FIB to form a bridge-like structure a so called H-bar. The remaining H-bar is now able to relax its internal stresses. Based on its deformation which is measured by DIC the relaxed stress can be calculated using Hooke's law.

The other method is a three point bending setup to measure stress changes with changing temperature similar to a wafer curvature experiment. A bending beam of ~5 x 5 x 20 mm^3 is mounted in a three point bending setup in a thermomechanical analysis machine. Upon thermal cycling in a Nitrogen atmosphere the sample bends and the measured deformation allows calculating the stress change in the coating system using Stoney's equation.

While the FIB-DIC method reveals local residual stresses at ambient temperature, the beam bending method creates a stress-temperature profile of the entire system.

First findings show a stress increase on cooling of about 1 GPa and local stresses of ~ -330 MPa after several thermal cycles. Stress changes of a similar magnitude were already calculated in the literature.