CRACK HEALING BEHAVIOUR OF A Cr$_2$AlC CERAMIC

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ABSTRACT

MAX phase materials exhibit a combination of attractive properties [1-4]. They have a high strength and yet are relatively ductile. The materials have a good electrical and thermal conduction. Due to their oxidation and corrosion resistance as well as to thermal shock resistance, they can be used at high temperatures and in aggressive environments. Recently, MAX ceramics like Ti$_3$AlC$_2$[5] and Zr$_2$Al$_4$C$_5$[6] were shown to exhibit another attractive property, namely: crack healing upon exposure to high temperatures. While the degree of healing of healing in these grades of MAX ceramics was shown to be rather high, it seems likely that the presence of either weak TiO$_2$ or weak ZrO$_2$ in the oxide filling the crack, must have a negative effect on the healing efficiency. Hence in this work we explore the healing efficiency of another MAX ceramics, Cr$_2$AlC, for which both oxides Al$_2$O$_3$ and Cr$_2$O$_3$ are expected to have a high strength at elevated temperatures.

To this aim, in the present study, a dense and fine-grained Cr$_2$AlC ceramic (~ 2 µm) was produced by mechanically activated sintering; see Fig.1. Its crack healing behaviour as a function of temperature, healing time and crack size was studied quantitatively. This ceramic is able to heal indentation-induced cracks in the range of 0.3-2.5 mm when exposed to 1100 ºC for 4 hours in air; see Fig.2. The main crack-healing mechanism is that cracks are filled by the formation of oxide, α-Al$_2$O$_3$, with minor amounts of Cr$_3$O$_3$. Cracks before and after healing were characterized by scanning electron microscopy and X-ray tomography. The compositions in the crack-healed zones were analyzed by X-ray diffraction and electron probe micro analysis (EPMA). The healing efficiency of the Cr$_2$AlC ceramic compared favourably to that of MAX ceramics studied earlier.

Figure 1: Microstructure of a fine-grained Cr$_2$AlC
Figure 2: Backscattered electron image of the healed crack after healing at 1100 °C for 4 h. The indentation induced crack was healed by the formation of $\alpha$-Al$_2$O$_3$ with minor amounts of Cr$_2$O$_3$.

REFERENCES


