3rd International Conference on Self-Healing Materials
Bath, UK. 27-29 June 2011

HIGH TEMPERATURE HEALING OF TI_2ALC

H.J. Yang, Y.T. Pei, J.C. Rao, J.Th.M. De Hosson

Department of Applied Physics, Zernike Institute for Advanced Materials and Materials Innovation Institute, University of Groningen,
Nijenborgh 4, 9747 AG Groningen, the Netherlands
Email: huajie.yang@rug.nl, y.pei@rug.nl, j.rao@rug.nl, j.t.m.de.hosson@rug.nl

Keywords: Self-healing, Ceramic, MAX phase, Oxidation, FIB

ABSTRACT

The layered ternary Ti_2AlC ceramic belongs to the $M_{n+1}AX_n$ phase (where n is 1, 2 or 3, M is an early transition metal, A is an A-group element, and X is either C or N) [1]. This carbide displays a unique combination of properties, including low density, high elastic modulus, high electrical conductivity, good thermal conductivity, easy machinability, excellent thermal shock resistance and damage tolerance. Such unique properties make the material attractive as structural components for high-temperature applications, oxidation-resistant coatings, and as conducting ceramic in harsh environments.

However, a common drawback of ceramics is crack sensitivity, which restricts its application area. Recently self-healing ability of Ti_3AlC_2 ceramic has shown to increase its reliability [2]. To make a material self-healing, it is necessary that cracks disappear and propagation is obstructed. In particular open cracks have to be filled with the new material with the ability to restore repair locally the load-bearing capability [3].

This contribution concentrates on optimizing the healing conditions of Ti_2AlC ceramics at high operating temperatures in an oxygen atmosphere. The microstructures of three kinds of surface defects: notches on single crystal, surface cavity and crack, after healing by oxidation in air at 1200 °C, were investigated in detail with the aid of scanning electron microscopy in conjunction with focused ion beam (FIB) cross-section milling techniques.

The notch-healing results reveal good healing efficiency since the material that filled in notches is Al_2O_3 with a compacted microstructure. The microstructure of oxides filled in the cavity depends on the size and shape of the cavity and the healing temperature. Large cavities with a “V” shape are healed by Al_2O_3 and TiO_2. In contrast, small cavity or cavities with a “L” shape are healed by Al_2O_3 alone. A multi-layered microstructure of oxides scales is observed on the cleavage plane, while only two layers of oxides form on the non-cleavage planes after oxidation of the fractured surface.

Financial support from the national IOP-Self Healing Materials program (Senter, the Hague, the Netherlands) is gratefully acknowledged.

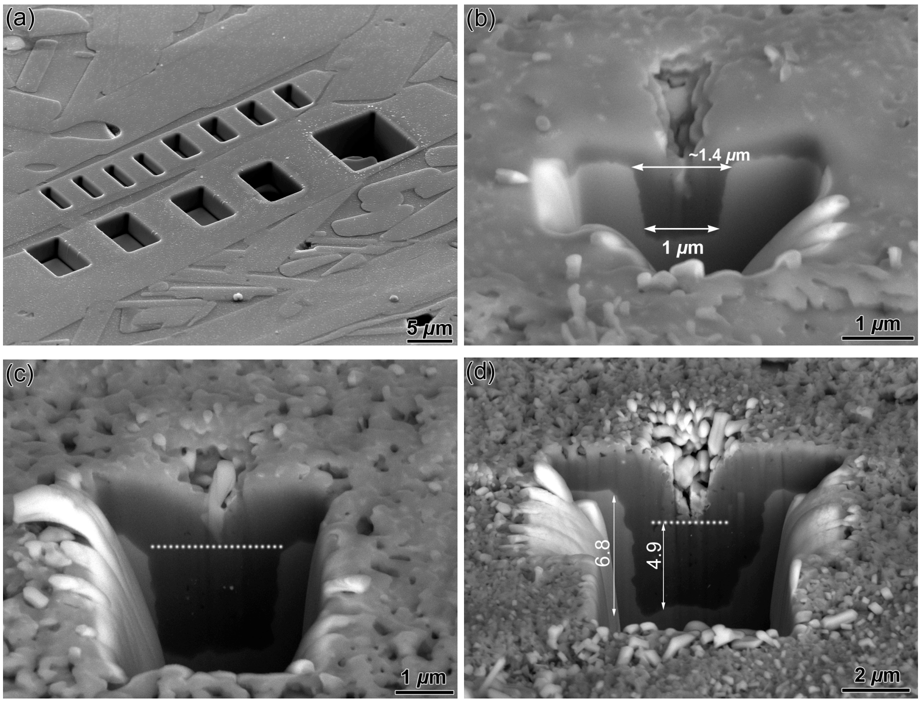

Figure 1. (a) Notches with various sizes, fabricated by FIB, on single crystal grains of Ti_2AlC. (b-d) The cross sections of the notches after healing at 1200 °C for 10 min， 30 min， 2 hrs, respectively.

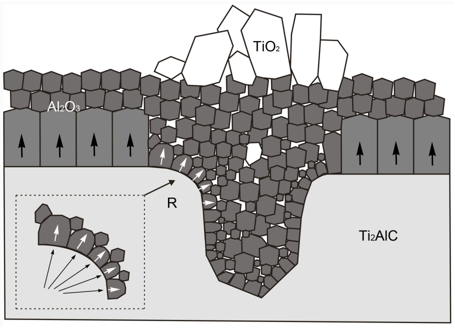

Figure 2. Schematic illustration showing the microstructure of healed cavity, indicating the influence of surface curvature on the formation of oxides scale. The arrows denote the directions of fast growth.

REFERENCES

[1] M. W. Barsoum, $M_{N+1}AX_N$phases: a new class of solids; thermodynamically stable nanolaminates. *Progress in Solid State Chemistry.* **28**, 2000, pp.201-281.

[2] G.M. Song, Y.T. Pei, W.G. Sloof, S.B. Li, J.Th.M. De Hosson, S. van der Zwaag, Oxidation-induced crack healing in Ti_3AlC_2 ceramics. *Scripta Materialia*. **58**, 2008, pp.13-16.

[3] S. van der Zwaag, J. M. S. Alexander, G. van der Zaken, Self healing materials: an alternative approach to 20 centuries of materials science, *Springer*, 2007, pp. 7-8