Oxidation Kinetics of Y_2O_3-doped ZrO_2 Composites Dispersed with Ni Particles

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INTRODUCTION

Functionally graded materials (FGMs) are promising materials for high temperature applications. Surface zone of heat-resistant FGMs can be regard as ceramics dispersed metal particles. When oxide ceramics are used as the matrix, metallic dispersion will be oxidized by oxygen permeation of the matrix at high temperatures. As almost metals expand by oxidation, the matrix receives stress from oxidized dispersion. Finally the matrix should be fractured. The aim of this paper is to establish a kinetic model of oxidation of ceramic composites with metallic particle dispersion. Here Y_2O_3-partially stabilized ZrO_2 with Ni particles is used as a model material to discuss the oxidation kinetics.

EXPERIMENTAL

Powder mixture of 3 mol % Y_2O_3-ZrO_2 (refer to YZ, 0.3 μm) and 1 to 5 vol% Ni (10 μm) were mixed in alcohol for 30 min. The powder mixture was sintered by the pulsed electric current pressure-sintering at 1300ºC under 34 MPa of uni-axial pressure for 30 min in vacuum.

Sintered samples were exposed at temperatures ranging from 600 to 800ºC in air. To examine the oxidation behavior, X-ray diffraction (XRD) and scanning electron microscopy (SEM) were carried out.

RESULTS AND DISCUSSION

Figure 1 shows cross-section of 5 vol% Ni/YZ oxidized at 800ºC for 8 h. The surface zone in depth of 200 μm has cracks between Ni particles. NiO and tetragonal ZrO_2 were identified by XRD. Figure 2 shows time dependence of the cracked zone depth. Growth of the cracked zone follows the linear manner. The slope, linear rate constant, k_l is plotted to reciprocal temperature as shown in Fig. 3. The apparent activation energy corresponds to 184 $kJmol^{-1}$, which agrees with the value of the hole conduction in Y_2O_3-doped ZrO_2[1]. Cracks are formed by oxidation of Ni due to oxygen permeation though YZ, which is rate-controlled by hole conduction. Atmospheric gas goes into cracks and oxygen diffuses though Ni below the cracks. New cracks form again by oxidation of Ni. The cracked zone grows by alternating this process. Temperature dependence of growth rate of cracked zone is equal to that of the hole conduction of YZ.

CONCLUSIONS

Oxidation of Ni particles/YZ shows surface cracked zone, which grows with the linear manner. Based on the apparent activation energy, growth rate of the cracked zone is rate-controlled by hole conduction of YZ.

REFERENCES
[1] J.H. Park et al., *J. Electrochem. Soc.*, **136** (1989) 2867.

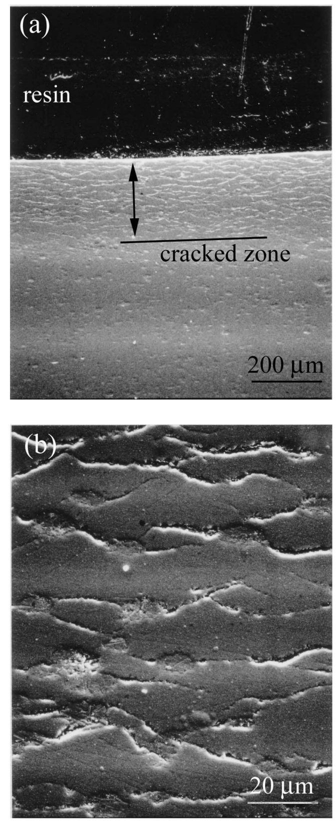

Figure 1 Cross section of 5 vol% Ni/YZ oxidized at 800ºC for 8 h in air. (a) low magnification and (b) high magnification

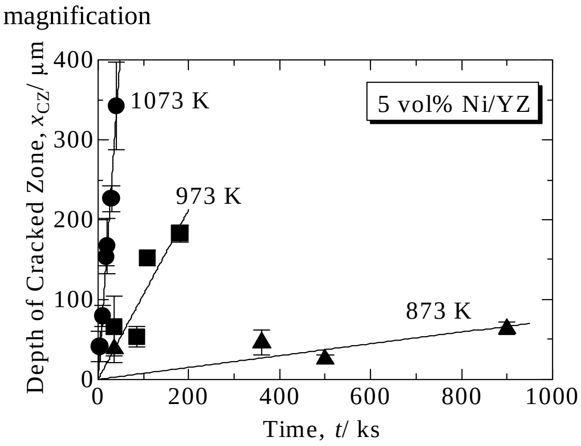

Figure 2 Depth of cracked zone as a function of time on high temperature oxidation of 5 vol% Ni/YZ in air

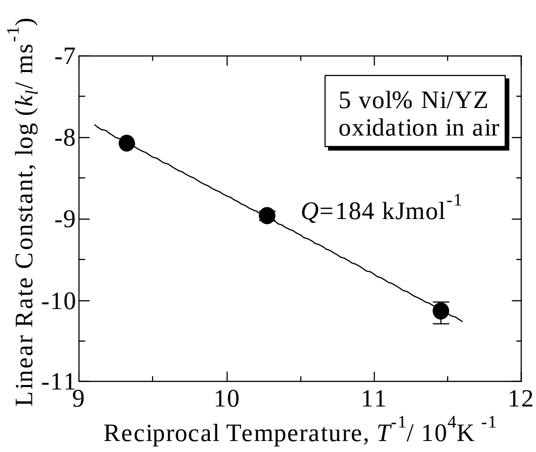

Figure 2 Temperature dependence of linear rate constant on growth of surface cracked zone of 5 vol% Ni/YZ.