Surface Deformation of Superplastic Materials at Elevated Temperatures

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Introduction

Indentation technique is definitely one of efficient experimental tools for examining viscoelastic deformation and flow of small-size ceramic materials at elevated temperatures. The time-dependent contact mechanics of viscoelastic bodies has been studied not only in theoretical [1] but also in experimental works [2,3]. The viscoelastic indentation tests for silicate glasses were conducted to obtain the rheological parameters and functions such as the steady-state viscosity, creep compliance function, stress relaxation modulus, and the retardation time spectrum by one of the present authors.

The microscopic mechanisms and processes of large-scale superplastic deformations have been widely examined in tensile tests. The present authors have proposed a novel microscopic process for superplastic elongation, i.e., the process of Cooperative Grain-Boundary Sliding (CGBS).

The intent of the present study is to examine the microscopic contact deformation mechanisms and processes that take place in an SP-TZP and an NSP-TZP in Vickers indentation creep tests.

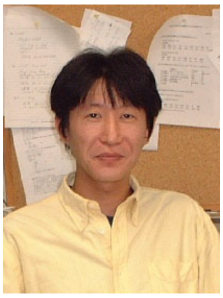
Experimental

A fully dense superplastic (SP) and non-superplastic (NSP) 3Y-TZP (supplied from Nikkato Co. Ltd., Ohtsu, Japan) were used as a test material. The dimensions of the specimens utilized in the indentation creep test are 10mm in the thickness and 225mm^2 (15×15mm) in the area of indentation plane. A Vickers indenter made of an SiC-ceramic was used in the indentation creep test. An external constant load P_o was applied to the indenter through the pushing rod by a dead weight via a mechanical lever. The load of indentation was monitored by a water cooled load cell (DB-200K, Showa Co., Ltd.) to confirm it to be kept constant during the creep test. The penetration depth $h(t)$ was measured with the precision of ±0.5μm by an electro-optical extensometer (UDM 5000, Zimmer GmbH) via detecting the gap between the indenter and the spacer block fixed on the specimen stage (see Fig. 1). The indentation creep tests was conducted at 1200±1.0 °C for the various indentation loads P_o ranging from 10 N to 100 N.

Results and Discussion

The indentation creep curves of SP-TZP exhibit a hardening behavior, i.e., the creeping rate decreases as the penetration depth and/or the creep time increases. In contrast, the indentation creep curves of NSP-TZP shows a steady-state viscous flow in its long-time creeping. The surface profiles of indentation impression after creep deformation suggest that the deformation mechanisms of indentation creep of SP-TZP and NSP-TZP are quite different. A well-defined piling-up impression profile is observed in SP-TZP, while it is sinking-in for NSP-TZP. This fact implies that the rearrangements of individual grains through grain-boundary sliding take place beneath the pyramidal indenter in SP-TZP, whereas the viscoelastic deformations and flows through bulk/grain-boundary diffusion processes dominate the indentation creep in NSP-TZP.

Biographical Sketch



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Dr. Hiroyuki MUTO received his BA degree in 1992 and received a PhD degree in materials science at Toyohashi University of Technology. He is currently a research associate of Department of Materials Science, Toyohashi University of Technology.

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