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1. Main Research Results

We aim to develop technology for increased reliability of ceramics, which will be key components for realizing secure systems. The main challenges are to provide basis for developing highly efficient superplastic forming of toughened ceramics. Furthermore, we are developing modeling and simulation technology to make more reliable ceramic components by controlling microstructural heterogeneity during sintering. The main research results are as follows;

1) Grain boundary network dynamics

A microscopic model is presented, which describes the sintering of equal-sized spherical particles that differ in phase. The three-dimensional computer simulation of interface-reaction-controlled sintering was conducted using the Surface Evolver program. The deviation of dynamic contact angle from its equilibrium value was proportional to the contact line velocity and inversely proportional to the triple junction mobility.

2) Superplasticity of nanocrystalline ceramics

(1) SiAlON nanoceramics

Nanocrystalline Ca-a SiAlON, which contain almost no intergranular glass phase, was developed. The SiAlON exhibited large plastic deformation with the stress exponent about 1 in the higher stress region, and n about 2 in the lower stress region. But, the shear-thickening creep, which is often observed in glass containing SiAlON was not observed in this material. This results show the mechanism of the shear-thickening creep is closely related to the presence of the glass phase

(2) Plasticity of Fe-oxypnictides superconductor

Recently an iron-based layered compound $\text{LaFeAsO}_{0.9}\text{F}_{0.1}$ has been reported to exhibit superconductivity. The distinctive feature of the unit cell is the presence of two types of layers with different natures: insulating LaO layer and metallic FeAs layer. We studied the plasticity of the new superconductor. Extraordinary large deformation (up to true strain of 1.6, the height of the specimen reduced to 1/5 of the original height) was observed at strain rate of 10^{-4} s^{-1} and 1673K. XRD revealed the preferential orientation along crystallographic c-axis occurred during deformation. The superconducting phase ($T_c = 16 \text{ K}$) could be retained after the deformation.

1. List of publication (original article, comment/book)

1) Original Paper

- (1) High-temperature compressive deformation of b-SiAlON polycrystals containing minimum amount of intergranular glass phase; Kentarou CHIHARA, Daisuke HIRATSUKA, Yutaka SHINODA, Takashi AKATSU, Fumihiko WAKAI, Junichi TATAMI, Katsutoshi KOMEYA: *Mater. Sci. Engn. B*, 148, 203-206 (2008).

- (2) Enhancement of high-temperature deformation in fine-grained silicon carbide with Al doping; Takuya TOKIYAMA, Yutaka SHINODA, Takashi AKATSU and Fumihiko WAKAI: *Mater. Sci Engn.B*, 148, 261-264 (2008).
- (3) Integrated molding of nanocrystalline tungsten carbide powder with stainless steel; Yutaka SHINODA, Takashi AKATSU and Fumihiko WAKAI: *Mater. Sci Engn.B*, 148, 145-148 (2008).
- (4) Microstructure and properties of ceramic particulate reinforced metallic glassy matrix composites fabricated by spark plasma sintering; Guoqiang XIE, Dmitri V. LOUZGUINE-LUZGIN, Fumihiko WAKAI, Hisamichi KIMURA and Akihisa INOUE *Mater. Sci Engn. B*, 148, 77-81 (2008).
- (5) Large-size ultrahigh strength Ni-based bulk metallic glassy matrix composites with enhanced ductility fabricated by spark plasma sintering; Guoqiang XIE, Dmitri V. LOUZGUINE-LUZGIN, Hisamichi KIMURA, Akihisa INOUE and Fumihiko WAKAI, *Applied Physics Letters.*, 92, 121907 (2008).
- (6) **Plasticity of Fe-Oxypnictides Superconductor**; Yutaka SHINODA, Sung-Wng KIM, Fumihiko WAKAI and Hideo HOSONO: *J. Phys. Soc. Jpn. Suppl. C*, 77, 125-126 (2008)
- (7) **High-temperature compressive deformation of SiAlON polycrystals prepared without additives**; Kentarou CHIHARA, Daisuke HIRATSUKA, Junichi TATAMI, Fumihiko WAKAI and Katsutoshi KOMIYA: *Key Engineering Materials*, 403, 117-120 (2009).

2) Review & Books

- (1) Flowing Nano-world-Superplasticity and Sintering; W. Wakai: Kouzan, 61, [4] 34-39 (2008)

2. Invited/Plenary Talks in Conference

1) International Conference or Workshop

- (1) F. Wakai, T. Akatsu and Y. Shinoda: Micro-mechanical principle in superplasticity and sintering (Invited). STAC2 & STSI1, OVTA, Chiba, 1 June, 2008.

2) Domestic Conferences

- (1) F. Wakai: Flowing nano-world – superplasticity and sintering (Invited). Nippon Kogyo Kyokai, Tokyo, 18 March, 2008.

3. Patent

- 1) High-Strength Cemented Carbide Bonded by Cu; JJP2008-49678

4. Others

1) Award

Fumihiko Wakai; Fellow, the American Ceramic Society (2008)

2) Others

J. Am Ceram Soc. Associate Editor

Science of Sintering, Associate Editor

J. Ceram. Soc. Japan, Editorial member