様　式　Ｃ－１９、Ｆ－１９－１、Ｚ－１９　（共通）

科研費 KAKENHI

科学研究費助成事業　　研究成果報告書

令和　元 年　 ６ 月 １０ 日現在

機関番号：８２１０８
研究種目：基盤研究(C)（一般）
研究期間：2015～2018
課題番号：１５Ｋ０６５１５

研究課題名（和文）酸化物セラミックスに対する通電効果の発現機構解明と応用に向けた基礎研究

研究課題名（英文）Research on the current effects on the high temperature phenomena of oxide ceramics and its applications

研究代表者

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研究者番号：２０３５４１８６

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研究成果の概要（和文）：多結晶ジルコニアセラミックの高温引張挙動に対する電流効果の解明を実施した。その結果、印可電流がある臨界値より低い場合、印加電流は試料温度を上昇させるが、変形速度を加速させることはない。一方、臨界値より高い場合、電流がない場合と比較して、通電は変形速度を約2倍以上加速されることを確認した。変形速度の増加は、ジュール加熱によるサンプル温度の上昇にのみでは説明できない。電流条件下で変形した試料をTEM-EDS分析法で消化した結果、粒界に沿って酸素空孔領域が形成されていることから、変形の増加が酸素空孔形成に関連していると結論できる。

研究成果の学術的意義や社会的意義
フラッシュ焼結で報告されているように、通電効果の効率的な利用が促進されれば、より低温・短時間で効果的に高機能セラミックスの創性が可能となる。通電効果を活用した高速創製プロセスの実現に向けた要素技術の構築には、通電効果をより効果的かつ効率的に制御するための、その支配因子の解明を通じた制御指針の確立が不可欠である。通電技術を確立することによって、フラッシュ現象の応用先は焼結技術のみに留まらず、革新的な鍛造加工・成形・接合、および修復技術などへの応用展開も見込め、先端産業への波及効果も期待できる。

研究成果の概要（英文）：In this work, the current effects were examined in the high temperature tensile behavior of polycrystalline zirconia ceramics. By applying the DC electric power higher than a critical value, the applied electric current increases sample temperature depending on the applied value, but does not enhance the rate of deformation. For higher than the critical value, on the other hand, the electric current enhances the rate of the deformation to about two times as compared with that of without current conditions. The enhanced deformation cannot be interpreted only by the increment of sample temperatures due to Joule heating. The TEM observation showed that oxygen vacancy areas are formed along grain boundaries. This suggests that the enhanced deformation would be related to oxygen vacancy formation.

研究分野：セラミックス材料

キーワード：セラミックス　通電効果　高温変形　酸素欠陥

HIP x HP

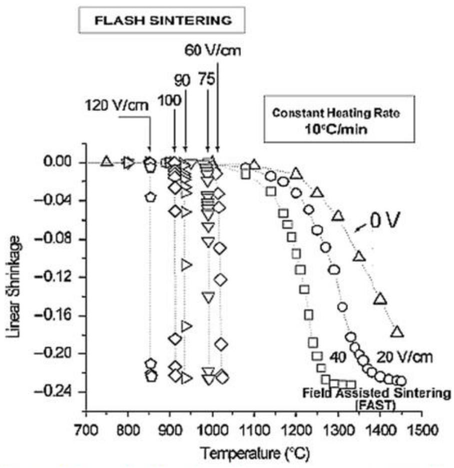
(SPS)

3Y-ZrO$_2$ [1-3]

-500

[2]

SPS



3Y-ZrO$_2$

[1] M. Cologna et al., *J. Am. Ceram Soc.*, 93(2010) 3556. [2] M. Cologna et al., *J. Euro. Ceram Soc.*, 31(2011) 2827. [3] R. Raj et al., *J. Am. Ceram Soc.*, 94(2011) 1941.

(1) (2)

8mol% Y_2O_3-ZrO_2 CIP

1523-1673K 2h 98

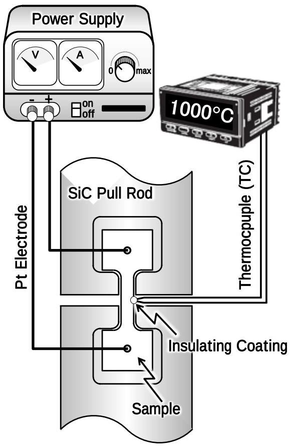
2 [4]

T_f = 1173: 1473K 1.5-50MPa

0.1-1.0

Su

Thermocouple (TC)

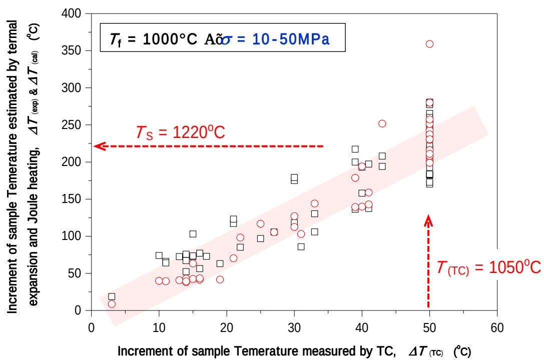


[4]

[4] K. Morita, H. Yoshida, B.-N. Kim, K. Hiraga, Y. Sakka, to be submitted.

T_f = 1273K

1.5MPa



$T_{s(TC)}$ $T_{s(TC)}$ [4]

$T_{s(exp)}$

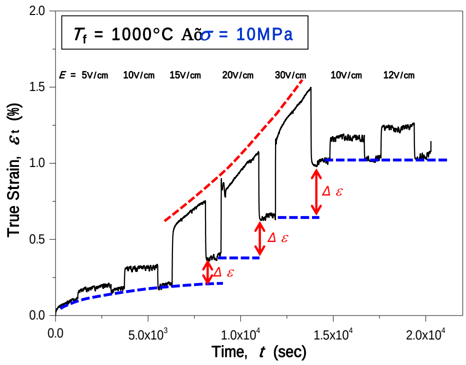
[5,6] [7,8]

$T_{s(exp)}$ $T_{s(cal)}$ $T_{s(TC)}$

$T_{s(TC)}$ $T_{s(exp)}$ $T_{s(cal)}$

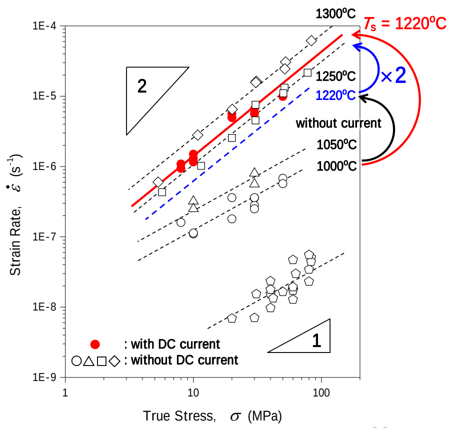
T_f $\Delta T_{s(TC)}$ $\Delta T_{s(exp)}$ [4] $\Delta T_{s(TC)}$ $\Delta T_{s(exp)}$ $T_f = 1273K$ $\Delta T_{s(TC)} = 50K$ $\Delta T_s = 220K$ $T_s = 1220K$ $\Delta T_{s(TC)} = 50K$

[5] S. P. Terblanche, J. Appl. Cryst., 22 **(**1989**)** 283**.** [6] C.-H. Chen, et al., J. Crystal Growth, 219 (2000) 253. [7] D. Yang et al., J. Am. Ceram.Soc., 93 (2010) 2935. [8] H. Yoshida, T. Yamamoto, J. Jpn. Soc. Powder Powder Metall., 64 (2017) 523.



$T_f = 1273K$ 10MPa [4]

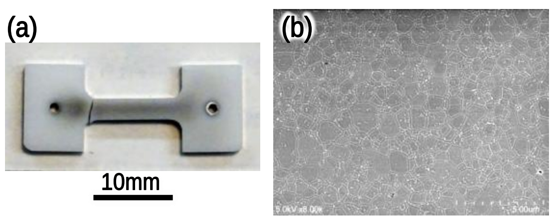
W 4 [4] $T_f = 1273K$ 10MPa 30V/cm 12V/cm off 15V/cm 12V/cm off 15V/cm $\Delta\varepsilon$



$\dot{\varepsilon}$ σ [4]

$\dot{\varepsilon}$ σ 5[4] $T_f = 1000$¥ $\Delta T_{s(TC)} = 50$¥ $T_s = 1220$¥ T_f 1250¥ 1300¥ $T_s = 1220$¥ 2 $\dot{\varepsilon}$-σ n $n = 2.0$

6 6(a)



(a) (b) SEM [4]

rS2n7ÂĀ§& SEM¥ZQb (ý))ĒÛKS)ŴW 6(b)&gM 37ĝĐ%T,c1u§vbbQb)(•))Ê2A3H(• S4 &gKZ ĝS3QKZvA)ÊÇc 1u ĈGbGc %T,7VEd37ĝIO S ¥Ź 37ĝĝ ĝ))ÊÕ LZ8GĈ&g@Z8•

ğ))ÊĈ40ÛMSu34ÂĀ§& TEM§40ÂWS)ŴW 7[5]&gM37ĝĝ-MSu T_f = 1000¥ ĝZĐ † T_s ≈ 1300¥ &ĐQ!OS37ĝIO S)ÊŴZ TEM 0ǹj KSĝbÂŶ 2 %&bŒ¢bbW4 b)Ý])(Ê ĝĝĝ ĝ8§-48c&1[A?WSSTK EDS ¥S(ô x0ÛŴS)ĈŒWZ gBIŹ8GĈ@1I&W 7[5]> Gb)ŶW 6 ĝZ0ĝI6%T,@ŴZgBI64@ | WZÊÕ Z8GĈ&g@Z8• ¥ ĝp7ÂÁ3MG[ŀv ÑŶZW@@BI6)1=[A•

[5] K. Morita et al., to be submitted.

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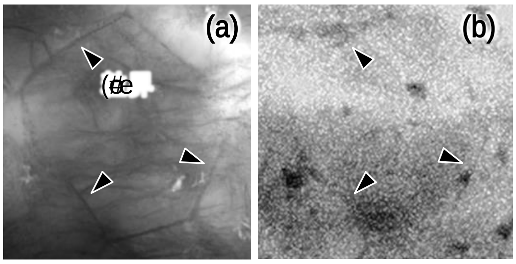

(a) STEM (b) EDS [6]

4 [6]I¢Ý (¥Mm~ ĝ37Z81ÂM GĈA• [6] Y. Dong, L. Qi, J. Li, I.-W. Chen, Acta Mater., 126 (2017) 438.

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