ELEVENTH ANNUAL CONFERENCE

YUCOMAT 2009

Hotel “Plaža”, Herceg Novi, Montenegro, August 31 - September 4, 2009
http://www.mrs-serbia.org.rs

Programme
and
The Book of Abstracts

Organised by:
Materials Research Society of Serbia,
and
Institute of Technical Sciences of the Serbian Academy of Sciences and Arts, Belgrade

under the auspices of
Federation of European Material Societies
and
Materials Research Society

Title: THE ELEVENTH ANNUAL CONFERENCE
"YUCOMAT 2009"
Programme and The Book of Abstracts

Publisher: Institute of Technical Sciences of the Serbian Academy of Sciences & Arts
Knez Mihailova 35/IV; P.O. Box 377, 11000 Belgrade, Serbia
Phone: +381 11 2185-437; Fax: + 381 11 2185-263
http://www.itn.sanu.ac.rs

Editor: Prof. Dr. Dragan P. Uskoković

Technical editor: Aleksandra Stojičić

Cover page: Aleksandra Stojičić and Milica Ševkušić

Acknowledgment:

Printed in: Printing office "Čigoja"
Studentski trg 15, 11000 Belgrade
Phones: + 381 11 2186-725; + 381 11 625-954
Circulation: 300 copies. The end of printing: July 2009.

ISBN 978-86-80321-18-9

9 788680 321189

CIP – Каталогизација у публикацији
Народна библиотека Србије, Београд

66.017/.018(048)

MATERIALS Research Society (Beograd). Conference (11 ; 2009 ; Herceg Novi)
Programme ; and The Book of Abstracts / Eleventh Annual Conference YUCOMAT 2009, organized by Materials Research Society of Serbia and Institute of Technical Sciences of the Serbian Academy of Sciences and Arts, Belgrade ; [editor Dragan P. Uskoković]. – Belgrade : Institute of Technical Sciences of SASA, 2009 (Belgrade : Čigoja).– L, 219 str. ; 24 cm

Tiraž 300. – Registar.

ISBN 978–86–80321–18–9
1. Materials Research Society (Beograd) 2. Institute of Technical Sciences of SASA (Beograd)

a) Наука о материјалима – Апстракти b) Технички материјали – Апстракти
COBISS.SR–ID 168339724

O.S.B.11.

$BaTi_{0.975}Sn_{0.025}O_3/BaTi_{0.85}Sn_{0.15}O_3$ FUNCTIONALLY GRADED MATERIALS: MASTER SINTERING CURVES AND ELECTRICAL PROPERTIES

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The most important aim in the design and processing of functionally graded materials (FGMs) is to obtain high-quality microstructure, and to produce devices free from any form of deformation. During sintering of BTS2.5/BTS15 FGMs, barium tin-titanate powders with different tin content ($BaTi_{0.975}Sn_{0.025}O_3$ and $BaTi_{0.85}Sn_{0.15}O_3$, denoted as BTS2.5 and BTS15, respectively) show different shrinkage rates and different extents of shrinkage, as well as different final density. This phenomenon can lead to excessive shape distortion, warping, delamination, crack development and microstructural damage in the FGMs. Therefore, to achieve high-quality FGM it is desirable to predict the sintering process for each layer in FGM and to design sintering strategies. The master sintering curve (MSC) model is suitable approach to make quantitative predictions of the densification behavior, and to design sintering procedure to prepare high-quality ceramics. Here, BTS2.5/BTS15 FGMs are prepared by the powder-stacking method and uniaxially-pressing process, followed by sintering. The MSCs were constructed, for BTS2.5 and BTS15 graded layers in FGMs, using shrinkage data obtained by a heating microscope during non-isothermal sintering up to 1420 °C with heating rates of, 2, 5, 10 and 20 °/min. The effective activation energies, determined using the concept of MSC, were 359.5 and 340.5 kJ/mol for graded layers BTS2.5 and BTS15, respectively. A small difference of the effective activation energies of chosen powders allowed preparation of high-quality FGMs, without delamination, distortion or other forms of defects.

Electrical characteristics of such BTS2.5/BTS15 FGMs prepared by non-isothermal sintering were determined by an *ac* impedance spectroscopy (*IS*). The *IS* results were used to distinguish the grain-interior and grain boundary resistivity of the ceramics, furthermore, to calculate activation energies for ionic conductivity. The activation energy as deduced from grain-interior conductivity is defined by chemical composition and does not depend on microstructure, while activation energy from grain boundary conductivity is influenced by microstructural development (density and average grain size), and vary for differently non-isothermally treated BTS2.5/BTS15 FGMs. No point dissipation is observed by *IS*, confirming that no insulator interfaces (cracks and/or delamination) between graded layers exist. We found that a smart choice of the heating rate during sintering is important for the fabrication of FGMs with desired electrical properties.