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Electric Field Assisted Sintering and Related Phenomena Far From Equilibrium

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Bala Vaidhyanathan
Loughborough University, b.vaidhyanathan@lboro.ac.uk

MICROWAVE AND FLASH PROCESSING OF FUNCTIONAL MATERIALS: ARE THERE (M)ANY SIMILARITIES?

Bala Vaidhyanathan*, Annapoorani Ketharam and John A. Downs

Department of Materials, Loughborough University, Loughborough, Leicestershire, LE11 3TU, United Kingdom. Email: B.Vaidhyanathan@lboro.ac.uk

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Electroceramic devices such as varistors and capacitors are used in most of the modern day electronic appliances and constitute a multi-billion$ market. Conventional fabrication methods of these devices involve high sintering temperatures and long processing time. Since sintering controls the electrical properties, it is necessary to develop simpler and less demanding processing methods. Microwave sintering (MS) was demonstrated to be a viable alternative for rapid processing electroceramics as they respond to the E-field component of the electromagnetic radiation. In a recent report on 'flash sintering' (FS) it was demonstrated that full sintering of dog-bone shaped zirconia ceramics can be achieved at 850^{o}C in just 5 seconds (at moderate E-fields) rather than normally used 1450^{o}C for few hours. This opens up the possibility of achieving significant energy savings during manufacture and the ability to produce fine grained ceramics. However the exact mechanisms by which this phenomena occur is not fully clear yet and the methodology is untested for the sintering of other complex functional materials. At Loughborough we investigated the feasibility of sintering nanocrystalline ZnO-varistors, $BaTiO_3$-capacitors and CCTO dielectrics using both MS and FS methods along with simultaneous measurements of shrinkage, online thermal distribution mapping and atmospheric control. This allowed the fabrication of disc-shaped functional ceramic devices using both these techniques and the properties of the devices are compared with conventionally sintered components. This talk will review these new developments on FS along with the operative mechanisms in comparison with microwave processing.