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Flash sintering of complex oxides

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High quality $BiFeO_3$ ceramics obtained by FLASH sintering

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$BiFeO_3$ is one of the most promising multiferroic (materials combining two or more ferroic properties in the same phase) materials. Preparation of high quality $BiFeO_3$ ceramics is quite challenging. The temperature required for processing is relatively high and partial decomposition takes place damaging the properties of the material. Moreover, the Curie temperature of $BiFeO_3$ is within the same temperature range required for conventional sintering. The volume change during Curie transition produces damage in the obtained pellets.

In this work high density ceramics of BiFeO3 have been obtained from nanostructured powders, prepared by direct mechanochemistry, followed by FLASH sintering. For FLASH sintering experiments, the original set up developed in Prof. Raj's lab has been used using linear heating rate. Effect of Flash sintering conditions, namely applied voltage and current intensity, has been investigated. It has been observed that for applied voltages of 50 Vcm^{-1} or larger sintering occurs almost instantly once certain temperature is reached, corresponding to a FLASH regime. For lower applied voltages densification takes place progressively in a kind of field assisted or FAST regime. For FLASH experiments, densification takes place at furnace temperatures at low as 480ºC within few seconds, while conventional heating requires temperatures above 850ºC. Interestingly, under FLASH conditions pure phase materials with high density were obtained, while for those materials obtained in the FAST regime mixtures were obtained. This behavior could be explained by the effect of applied voltage on the temperature of the Curie transition. Electrical properties of the samples obtained by FLASH were characterized using complex impedance spectroscopy at different temperatures. It was concluded that resulting materials were electrically insulating. It is worth mentioning that no reduction in the sample was observed, while for samples prepared by spark plasma sintering (SPS) it has been previously reported lower resistivity and activation energy values due to reduction in the samples during the SPS experiment.