# Understanding the effect of ZnO addition and SPS sintering on KNN densification by using transmission electron microscopy

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The piezoelectric materials are currently one of the most widely used functional materials. Although, lead based piezoelectrics have an important role among all piezoelectric materials they are hazardous to human body and environment. Therefore, alternative material systems are being investigated since E.U. and other countries decided to reduce the usage of lead containing materials. Potassium sodium niobate (KNN) is one of the important lead-free piezoelectric materials. Having good piezoelectric properties but suffering from densification problem [1]. For this reason, several methods have been used such as hot pressing, spark plasma sintering or sintering in the presence of additives. ZnO is found to be one of the most efficient additives investigated so far [2-3]. To understand the effect of spark plasma sintering (SPS) and ZnO addition on the KNN densification, transmission electron microscope (TEM) study is performed on ZnO added KNN samples which are sintered in SPS. First, 2 mole % ZnO added sample was sintered at 1050°C, for 5 min., under 50 MPa pressure in SPS. Microstructural development, composition and distribution of phases in the KNN system was investigated by using 200 kV field emission TEM (Jeol 2100F) attached with an energy filter (Gatan GIF Tridiem), electron energy loss spectrometer (EELS), a high angle annular dark field scanning transmission electron microscope (STEM-HAADF) detector and an energy dispersive x-ray (EDX) spectrometer. STEM analysis showed that ZnO particles were observed both inside the KNN grain and at grain boundaries. ZnO particles remained intact in KNN (Fig.1) as a result of very fast heating and pressure during SPS. Furthermore, EDX analysis, which is taken from annealed sample at 950°C, showed a diffusion layer near ZnO particle (Fig. 2). Analyses showed that the reaction between KNN and ZnO particles do not complete in SPS, because of the pressure and fast process. The reaction between KNN and ZnO particles would progress if enough time is given during annealing.

References

[1] S. J. Zhang et. al , *J Electroceram*, 19 (2007).
[2] S. Park et al., *Japanese Journal of Applied Physics* 34 (2004) 1072.
[3] R. Zuo et al., *The American Ceramic Society*, 89 (2006) 2010.

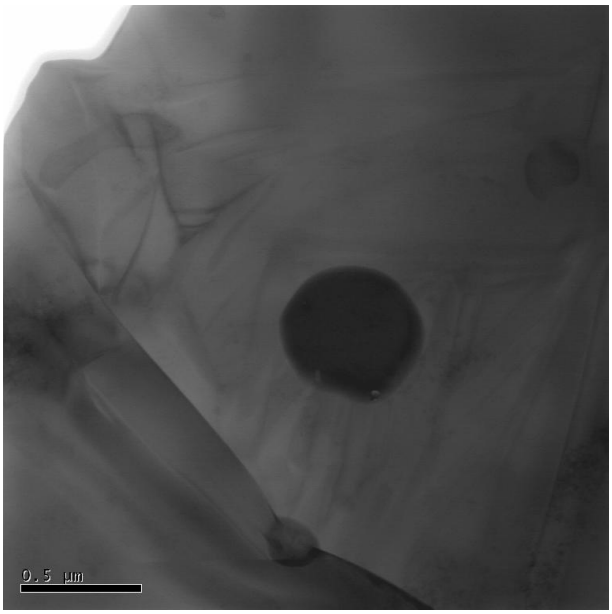


Fig. 1 STEM BF image which are taken from KNN sample sintered at 1050°C SPS.

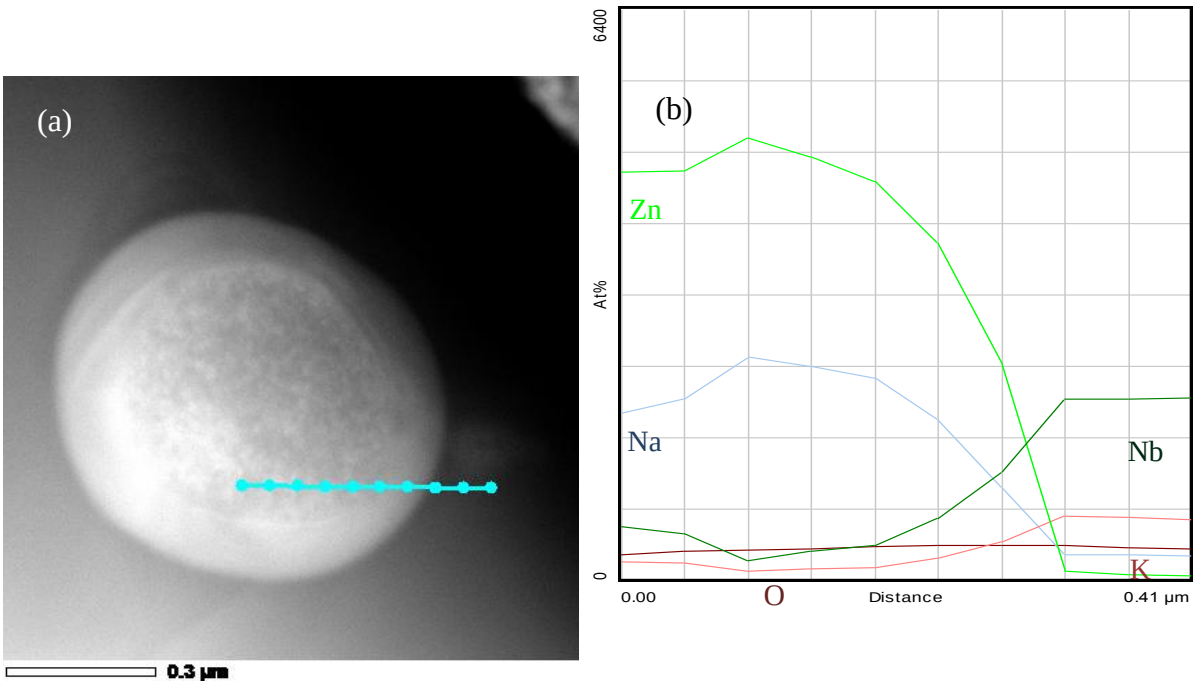


Fig. 2 STEM HAADF (a) and EDX analysis (b) which is taken from sample which is annealed at 950°C 5 hour.