Development of lead free dielectrics for energy storage application

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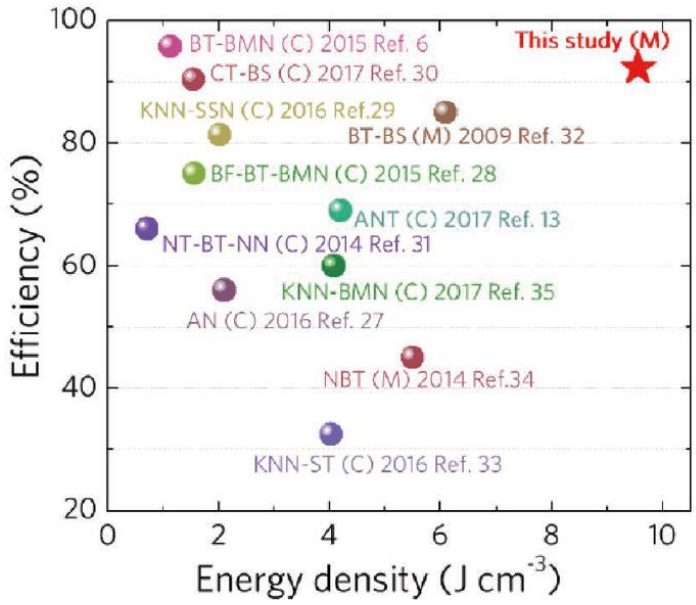
Electrical energy storage devices are essential elements for advanced electrical power systems. Compared to electrochemical energy storage devices such as batteries and electrochemical capacitors, dielectric capacitors possess the highest power density, owing to their fast charge–discharge capability, thus, playing an important role in high power applications, such as high power microwaves, electromagnetic devices, hybrid electric vehicles (HEVs), etc. The energy density of dielectric ceramics is much lower than that of polymers, being associated with their low dielectric breakdown strengths, which limit their applications for energy storage.

In this research, we propose to simultaneously achieve high energy density and efficiency in a dielectric ceramic by combining antiferroelectric and relaxor features. Based on this concept, we investigate lead-free dielectric $(Na_{0.5}Bi_{0.5})TiO_3$-based system and fabricate the corresponding multilayer ceramic capacitors. A record-high energy density of 9.5 J cm^{-3}, together with high energy efficiency of 92%, has been achieved in NBT-0.45SBT multilayer ceramic capacitors[1]. Furthermore, the newly developed capacitor exhibits a wide temperature usage range of -60~120 ^{o}C with energy density variation being less than 10%, and a good cycling reliability with degradation being less than 8% over 10^6 cycles. These characteristics demonstrate the NBT-based multilayer ceramic a promising candidate for high-power energy storage applications.



The energy density and efficiency of NBT-0.45SBT MLCC compared to the state-of-the-art dielectric materials

Reference:
[1] J. L. Li, et al., Adv. Mater. 30, 1802155 (2018).