Hard-Piezoelectric Ceramics for Low Temperature Co-Fired Multilayer Piezoelectric Transformers

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Hard-piezoelectric ceramics have been widely used high power applications such as ultrasonic motor, actuators and piezoelectric transformers (PT's). These piezoceramics typically have high sintering temperatures (~1200˚C). In order to combine PT's with multilayer technology to improve the power level, one has to use a suitable electroding metal, which can withstand high temperature sintering/co-firing conditions. Since the temperatures are high, co-firing metallization is pretty much limited to quite expensive platinum (Pt), unfortunately. Electrode materials alternative to Pt would bring down the cost significantly and improve the performance due to decreased electrical losses.

Recently, some ternary high-power piezoelectric ceramics were synthesized by adding perovskite structure relaxors into the PZT system, such as PZT–PMS, PZT–PMN, PZT–PMS–PMN, and PZT–PMS–PZN to apply for high-power piezoelectric actuators. These compositions, however, are still not satisfactory for multilayer PT's due to high sintering temperatures. Therefore, flux materials were added to decrease the sintering temperature to or below 1000˚C.

Base metal electroding (e.g., Cu and Ni) is the cheapest option for multilayer applications. Due to possible reactions between Ni and lead-based systems, Cu was chosen as the base metal option. Yet, Cu oxidizes under conventional sintering conditions. Reducing atmosphere is needed to keep Cu in the metallic form. Therefore, material properties under reducing conditions will also be discussed.