Comparison of Sintering Aids for Low Temperature Sintering of Hard PZT

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Introduction

- PZT (PbZrTiO₃) is the most commonly used piezo ceramic
- 100 µm thick PZT-films were fabricated by tape casting method and sintered in air at 900 °C instead of normally needed 1200 °C
- Used Technique:

  **LIQUID-PHASE SINTERING**
  Acceleration of densification of the major phase particles (PZT) by adding of lower melting sintering aids which form a liquid phase and facilitate the rearrangement and grain growth of the matrix phase at significantly reduced sintering temperatures.

Results

Sintering aid amount
Contents of Li-compounds above 1 vol-% deteriorate the piezoelectric prop. of PZT.

- + Li₂CO₃
- + Li₂O
- + MnO₂
- + V₂O₅
- + PdO
- + LBCu
- + CuO
- + Cu₂O-PbO

Piezoelectric Properties
A sufficiently dense microstructure and the highest piezoelectric charge constant dₑₑ at 181 pC/N provide the @ 900 °C for 3h sintered PZT-films with sintering aid LBCu (2 vol%).

Conclusion

- Most effective sintering aid for hard PZT is the ternary system LBCu (Li₂CO₃:Bi₂O₃:CuO; 1:1:4).
- Highest densification progress of PZT particles with a relative density of 97 ± 3 % and highest characteristic breaking strength of PZT-films sintered @ 900 °C was achieved with 5 vol-% LBCu as sintering aid.
- Highest piezoelectric charge constant in average (181 pC/N) was measured for PZT-films with 2 vol-% LBCu.
- The combination of hard PZT and CuO leads to increased piezoelectric properties, while contents of Li-compounds in the investigated volume range deteriorate the piezoelectric properties of PZT significantly.

Advantages of LT-Sintering of PZT

- **MATERIAL COMPATIBILITY**
- **STABILIZATION OF ELECTROMECH. PROP.**
- **REDUCTION OF PROCESS COSTS**

  - Co-firing of multilayer stacks made from PZT- and LTCC-layers or Internal electrodes from pure Ag
  - Evaporation of volatile PbO out of PZT during the sintering process is suppressed, so that stoichiometric composition of PZT is stabilized and subsequent piezoelectric components become more reliable
  - Less cost-effective electrodes from Ag instead of Pt or Ag/Pd-alloys
  - Less environmental pollution through evaporation of Pb-compounds

Mechanical stability
High characteristic breaking strength σ₀ above 150 MPa were obtained for addition of V₂O₅-LBCu-CuO and higher amount of PbO, Bi₂O₃ or PbO-WO₃.

V₂O₅-Ligaments
Addition of V₂O₅ increases the mechanical stability by formation of V₂O₅-ligaments through the still porous PZT-matrix. Densification of the PZT particles remains low.

Outlook

Development of a new fabrication method for piezoelectric bimorphs and multilayer by Co-Casting a whole stack of alternating sheets from PZT and Ag instead of Tape Casting of single PZT green tapes, which have to be metallized individually, stacked properly and laminated without distortion.

Co-fired multilayer manufactured from lab scale for multilayer tailored by punching out. Access to the internal Ag-electrode realized by stacks manufacturing. Access to the internal Ag-stacked stacking with the problem that out of alternating cera-electrode was made by the undermost layer is not stable. mic and metal layers.

Co-Casting setup on first co-casted bimorphs metalized single green tapes. Access to the internal Ag-electrode realized by stacks manufacturing. Access to the internal Ag-stacked stacking with the problem that out of alternating cera-electrode was made by the undermost layer is not stable. mic and metal layers.

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Fig. 2. Co-fired multilayer with Ag ... tapes. 

Fig. 4. Co-casted bimorphs - tailoring and access to the inner Ag-electrode made by laser treatment.