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Thermal diffusivity of sintered NTC thermistors obtained by photoacoustic method

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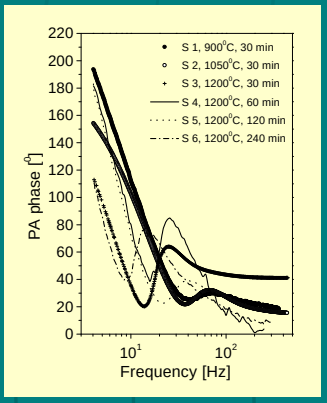
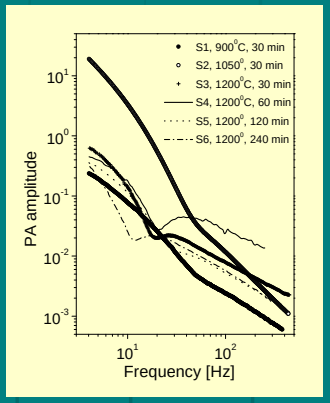
Abstract

Thermal diffusivity and electron transport parameters of sintered NTC samples were determined by the photoacoustic technique. Powder mixtures composed of MnO, NiO, CoO and Fe_2O_3 were milled to nanometer particle size. NTC discs were dry powder pressed and sintered at different temperatures in the range from 900°C to 1200°C for 30 minutes. A second group of NTC discs was sintered at 1200°C with the sintering time varying from 30 to 240 minutes. These NTC samples were polished and exposed to a chopped laser beam in order to plot a response in the acoustic range. The thermal diffusivity of sintered NTC layers based on a metal oxide powder mixture was measured at room temperature by the photoacoustic (PA) technique. An increase of thermal diffusivity with sintering temperature and time of sintering was observed.

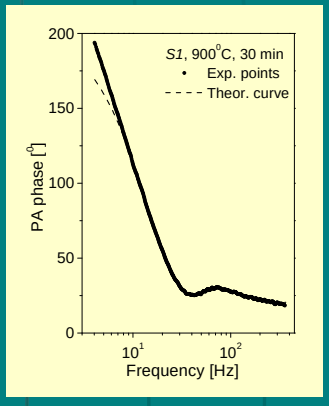
Experimental

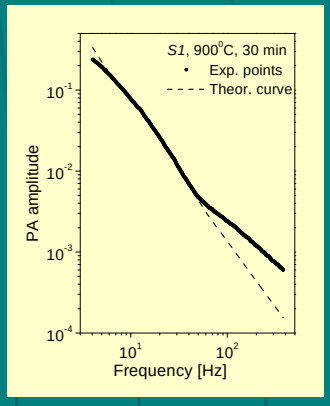
- Powder preparation:
  - Calcinating (1050°C, 60 min)
  - Ball milling (particle size-0.9μm)
  - Pressing (2.5 MPa)
  - Sintering conditions (900°C, 1050°C, 1200°C- 30 min; 1200°C –30, 60, 120, 240 min)
- SEM (JEOL JSM 6460LV)
- Photoacoustic measurements





Experimental phase and amplitude PA diagrams for NTC samples sintered in different conditions

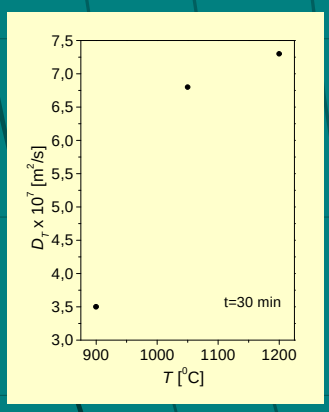




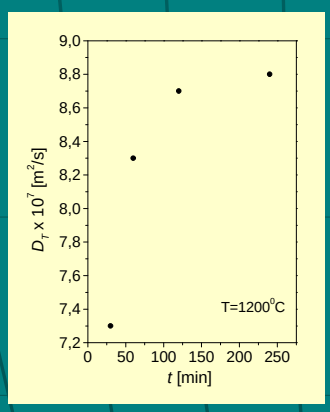
Experimental (points) and theoretical (dashed line) phase and amplitude PA diagrams for a NTC sample sintered at 900°C for 30 minutes.

Values of calculated parameters for sintered NTC samples

Sample	T [°C] / t [min]	D_T [m²/s]	τ [s]	D [m²/s]	μ [cm²/Vs]
1	900 / 30	0.35×10^{-6}	0.85×10^{-2}	0.47×10^{-7}	1.8×10^{-2}
2	1050 / 30	0.68×10^{-6}	0.78×10^{-2}	0.27×10^{-8}	2.7×10^{-4}
3	1200 / 30	0.73×10^{-6}	0.20×10^{-1}	0.34×10^{-7}	1.3×10^{-2}
4	1200 / 60	0.83×10^{-6}	0.10×10^{-1}	0.82×10^{-8}	3.2×10^{-3}
5	1200 / 120	0.87×10^{-6}	0.14×10^{-1}	0.32×10^{-8}	1.3×10^{-3}
6	1200 / 240	0.88×10^{-6}	0.12×10^{-1}	0.30×10^{-8}	1.2×10^{-3}

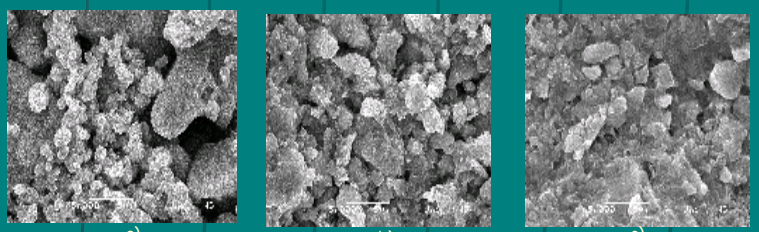


a)



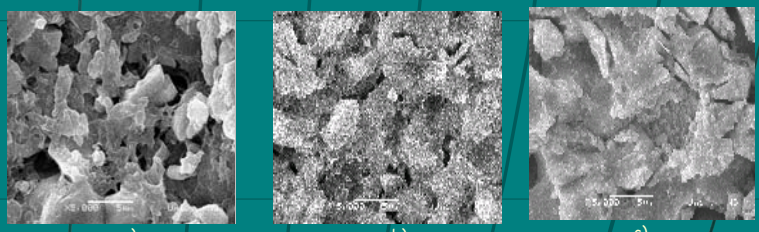
b)

Thermal diffusivity vs. temperature (a) and time of sintering (b) for different NTC samples



a) b) c)

SEM images obtained from surfaces of samples sintered for 30 minutes at different temperatures: 900°C (a), 1050°C (b) and 1200°C (c).



a) b) c)

SEM images obtained from surfaces of samples sintered at 1200°C for different times: 60 min (a), 120 min (b) and 240 min (c)

Conclusion

- The behavior of sintered NTC thermistors and changes in the microstructure after sintering are connected with thermal diffusivity and electronic transport properties
- Thermal diffusivity increases when the temperature and time of sintering rise
- This is a consequence of a corresponding microstructure-increase in interparticle contact, average grain size, material density and reduction of porosity when temperature and time of sintering rise