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Defect Chemistry and Losses in Piezoelectric Crystals at Elevated Temperatures

Sensors and high precision transducers base often on piezoelectrically excited acoustic waves. However, the use of conventional piezoelectric materials such as quartz is limited by the intrinsic materials properties to about 500 °C. Anticipated high-temperature applications including thermogravimetry on small volumes and gas sensing based on stoichiometry change of thin sensor films are feasible by applying materials that retain their piezoelectric properties up to higher temperatures.

Langasite ($La_3Ga_5SiO_{14}$) is a promising single crystalline piezoelectric material since it exhibits bulk acoustic waves up to temperatures of about 1470 °C. Factors limiting its potential use at elevated temperatures include excessive conductive and viscous losses, deviations from stoichiometry and chemical instability. The objective is to review the related microscopic mechanisms, to correlate electromechanical properties and defect chemistry and to improve the stability of the material by e.g. appropriate dopants.

The loss in langasite is found to be governed up to about 650 °C by viscoelastic damping related to the movement of oxygen ions. Based on langasite's defect chemistry donor doping is expected to lower that loss contribution and shown to be effective. Above 650 °C the impact of the conductivity related loss becomes pronounced. Here, lowering the conductivity results generally in decreased losses.

Further, the evaluation of langasite is focused on mapping the regimes of gas insensitive operation. The most relevant feature with respect to frequency fluctuations of resonator devices is the formation of oxygen vacancies. The calculated frequency shift induced by redox related reactions only exceeds the limit of ±4 Hz below 10^{-24} bar at 800 °C in nominally hydrogen free atmospheres. Water vapor is found to shift the resonance frequency at higher oxygen partial pressures. In the hydrogen containing atmospheres applied here, langasite can be regarded as a stable resonator material above oxygen partial pressures of 10^{-13} bar at 800 °C.

Die Vorträge finden, wenn nicht anders angegeben, jeweils um **16:15** im Gebäude der Materialwissenschaften, Lichtwiese, Petersenstr. 23, **Raum 77** statt