High-temperature Structural Disorder in α-quartz-type Piezoelectric Materials

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Piezoelectric materials are used at high temperature in important technological applications such as microbalances, pressure sensors and field-test viscometers. At room temperature in the α-quartz group of materials, the piezoelectric coupling coefficient can be related to the structural distortion with respect to the β-quartz structure type. Piezoelectric properties of α-quartz resonators, however, begin to degrade well below the α-β phase transition temperature at 846 K. In order to identify new higher performance materials, it is essential to develop structure-property relationships *in situ* at high temperature.

Quartz and the promising homeotypic material $GaPO_4$ were studied at high temperature by total neutron scattering and by piezoelectric measurements. In contrast to the results of Rietveld refinements of the average structure, reverse Monte-Carlo refinements using total neutron scattering data indicate that structural disorder in quartz significantly increases well below the α-β transition. In the case of $GaPO_4$, an increase in disorder is observed beginning above 1023 K. Piezoelectric measurements indicate that the quality factor of $GaPO_4$ resonators begins to degrade at this temperature. This degradation can be correlated to the increase in structural disorder. Gallium phosphate is thus a promising material for applications at temperatures up to 1000 K.

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