

Properties of CTGS ($\text{Ca}_3\text{TaGa}_3\text{Si}_2\text{O}_{14}$) crystals

CTGS ($\text{Ca}_3\text{TaGa}_3\text{Si}_2\text{O}_{14}$) is a piezoelectric crystal of the same crystal class as quartz. It is a member of the so-called Langasite family (general formula $\text{A}_3\text{BC}_3\text{D}_2\text{O}_{14}$) as Langasite (LGS) and Langatate (LGT). As opposed to quartz it has no phase transition up to the melting point at $\approx 1350^\circ\text{C}$. Therefore it is an excellent candidate for high temperature piezoelectric sensors.

The isolation resistivity ρ at higher temperatures is by 2 orders of magnitude better than that of LGT, i.e. $\rho = 1 \cdot 10^{11} \Omega \cdot \text{cm}$ (CTGS) instead of $1 \cdot 10^9 \Omega \cdot \text{cm}$ (LGT) @ 300°C (see Fig. 1)

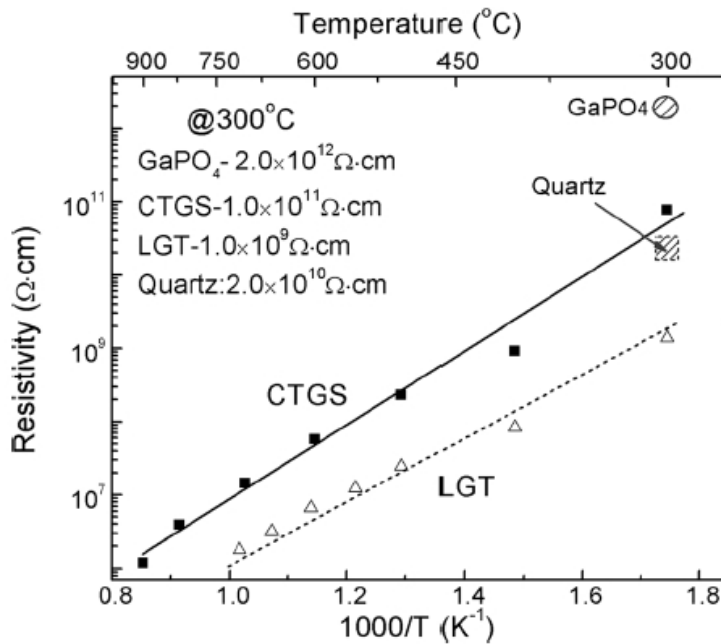


Fig.1: Resistivity ρ of CTGS vs. LGT, GaPO_4 and Quartz (Fapeng Yu et al., J Appl Phys **109**, 114103 (2011))

CTGS X-cut has a piezoelectric factor d_{11} of about $4 \sim 5 \text{ pC/N}$, which about twice the value of quartz. For rotated X-cuts the piezoelectric factor $|d_{26}|$ goes up to 11.5 pC/N at a cut angle of $(\text{YXl})-25^\circ$ (see Fig. 2)

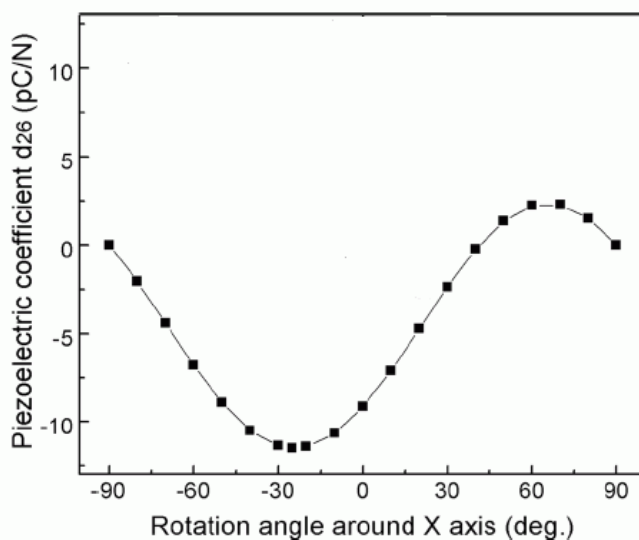


Fig.2: Piezoelectric factor d_{26} of CTGS (Fapeng Yu et al., J Appl Phys **109**, 114103 (2011))

This feature allows the realization of piezo sensors with high sensitivity.

The piezoelectric coupling factor k_{26} , which is important for the application as resonator, is much higher than for quartz, and reaches a maximum of 18.9% at a cut angle Θ of -30° (see Fig. 3)

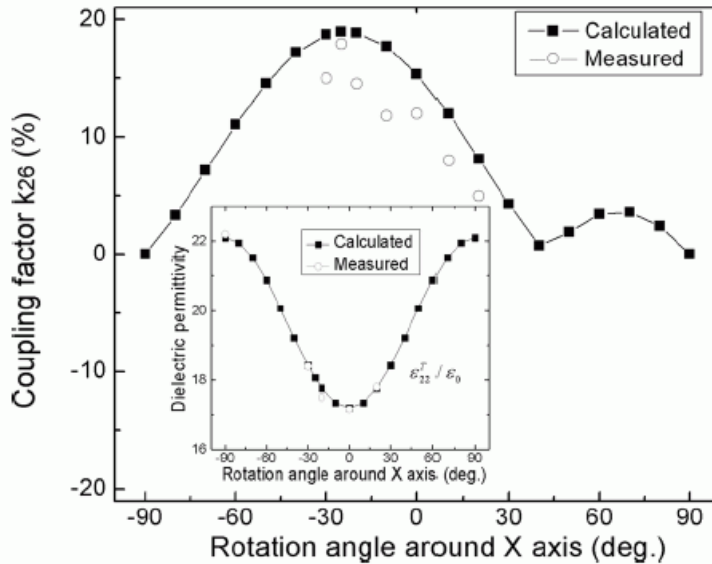


Fig.3: Piezoelectric coupling factor k_{26} of CTGS (Fapeng Yu et al., J Appl Phys **109**, 114103 (2011))

In a wide range of cut angles ($\Theta = -35^\circ$ to -20°) the frequency vs. temperature response can be described by a second order parabola with $a_2 \approx -0.065$ ppm/K, whereas its turnover temperature can be controlled by Θ between 330°C and -40°C (see Fig. 4). This allows to set a $f(T)$ characteristic with optimum frequency stability for a given (high) operating temperature.

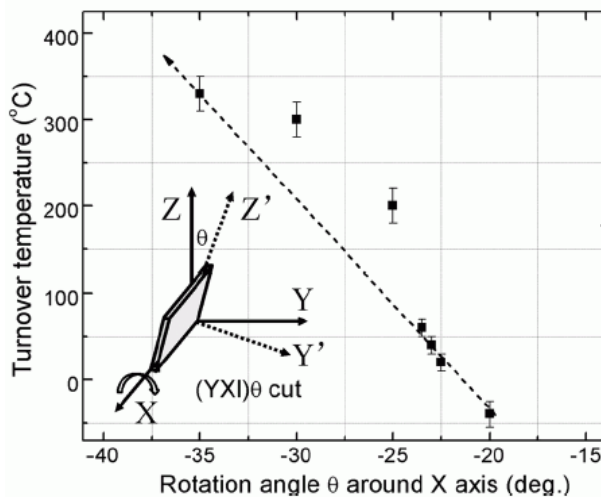


Fig.4: Turnover temperature vs. cut angle of CTGS (Fapeng Yu et al., J Appl Phys **109**, 114103 (2011))

For a positive cut angle of $\Theta = +10^\circ$ a linear frequency-temperature response with a slope of -42 ppm/K between at least 0°C and 650°C can be achieved, which makes CTGS resonators attractive as resonant temperature sensors.

Mosbach, November 2011