

Application of $\text{Ca}_3\text{TaGa}_3\text{Si}_2\text{O}_{14}$ single crystal in New Types of Modern Piezoelectric Devices

Piezoelectric filter based on $\text{Ca}_3\text{TaGa}_3\text{Si}_2\text{O}_{14}$ single crystals operating in a thickness shear mode was manufactured. The filter based on the crystal elements with angle cut $21^\circ 20'$ has frequency deviation less than 120 ppm in the operating temperature range from -40 up to 80°C .

Recently, new piezoelectric crystals that also operate at high temperatures have been introduced in wide bandwidth acoustic wave filters, frequency control, and high-temperature sensor applications. The study, production, and application of langasite family crystals have been rapidly developing in recent years. This crystal group is isostructural to $\text{Ca}_3\text{Ga}_2\text{GeO}_{14}$ and currently it includes around 100 compounds. One of the langasite family crystals is calcium tantalum gallium silicate ($\text{Ca}_3\text{TaGa}_3\text{Si}_2\text{O}_{14}$, CTGS).

CTGS single crystal belongs to the trigonal system (space group P321, point group 32) and shows peculiar properties such as low dependence of dielectric and electromechanical properties from temperature. Also, its large magnitude of piezoelectric modulus $d_{14} = 13.25$ pC/N allows to obtain high values of the coupling factor for different types of motion.

Fig.1 shows the variations of the coupling factor as functions of the rotation angle ψ around X-axis for different kinds of vibration mode. The maximum value of the coupling factor k_{12} for extensional mode is close to 24.8% observed for the angle $\psi = -37^\circ$. For rotated X-cut operating in a face shear mode the largest coupling factor k_{14} equals 23.96%.

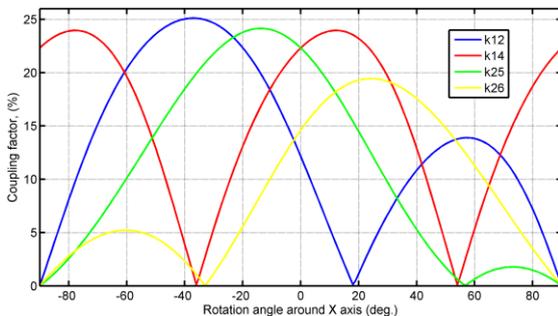


Fig. 1 Coupling factors as functions of rotation angle ψ

As was shown in [1], [2] and observed from Fig.1 the coupling factor k_{26} of thickness shear mode for temperature compensated cut $\text{YXl}/21^\circ 20'$ is close to 19%.

Using this cut a piezoelectric filter at nominal frequency 12 MHz with pass band width 75 kHz was manufactured. Fig.2 shows the typical attenuation characteristic of the filter. The deviation of cut-off frequencies was less than 1.5 kHz in the temperature range from -40 up to 80°C .



Fig. 2 Attenuation characteristic of CTGS filter

CTGS shows great potential and properties useful for resonators and filters based on temperature compensated cut at room temperature.

References

- [1] F. Yu, S. Zhang, X. Zhao, D. Yuan, L. Qin, "Investigation of $\text{Ca}_3\text{TaGa}_3\text{Si}_2\text{O}_{14}$ piezoelectric crystals for high temperature sensor," J. Appl. Phys. 109, 114103, 2011.
- [2] A. Medvedev, S. Sakharov, Investigation of the Electrode Coating Influence on the Frequency Temperature Characteristics of the Resonators Operating at the Rotated Y-Cut $\text{Ca}_3\text{TaGa}_3\text{Si}_2\text{O}_{14}$ Single Crystals, Joint UFFC, EFTF and PFM Symposium, 2013, p. 114-117

Keywords: crystal, piezoelectric, devices.

Full Name: Andrey Medvedev, OAO "Fomos Materials"

E-mail: medvedev@imr.tohoku.ac.jp

<http://www.newpiezo.com>