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Investigation of the extensional mode in $Ca_3TaGa_3Si_2O_{14}$ single crystals for high temperature application

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INTRODUCTION Langasite family crystals (point group 32, space group P321) have been attracting the attention of developers of the different devices operating on the direct and inverse piezoelectric effect from the mid-1980s till the present time. $Ca_3TaGa_3Si_2O_{14}$ (CTGS) single crystal belongs to langasite family is of special interest. CTGS has a large value of piezoelectric model d_{14} (absolute value is about 10 pC/N) [1], and a small frequency deviation in the temperature range (temperature frequency coefficient of the second order is about −0.026 ppm/(℃$^{-2}$) [2], −0.039 ppm/(℃$^{-2}$) [3]). In this work, we investigated the piezoelectric properties of the different CTGS cuts operating on the extensional mode of motion propagating along length of the plate for using in the resonators and sensors for high temperature application.

EXPERIMENTAL CTGS crystal was grown by the Czochralski method using iridium crucible in JSC «Fomos - Materials» (Moscow, Russia). The crystal was grown along ⟨01.0⟩ crystallographic direction; the crystal diameter was about 80 mm and the length of crystal was 90 mm. The plates were deposited gold electrodes by using quick coater (SC-701). The electrical resistance of the electrodes coating was less than 1 Ohm. The frequencies of series resonance (f_r) and parallel resonance (f_a) were measured with an Agilent precision impedance analyzer (4294A). The dielectric constants were measured at 1 kHz.

RESULTS AND DISCUSSION The values of the dielectric constants (ε_{11} , ε_{33}) and piezoelectric modules d_{11} , d_{14} were measured at the room temperature. Using these data were calculated piezoelectric module d'_{12} and coupling factor k'_{12} (Fig. 1) for rotated X-cuts operating on extensional mode propagating along length of the plate. From this figure we may see that of piezoelectric module d'_{12} has the maximum absolute value (8.9 pC/N) for the angle 36.25° and will be zero if the plate is orientated at −17.5°. Also, the impedance and phase characteristics of the samples with orientations (XYt)20° and (XYt) −20° were measured. For (XYt)20° cut the values of piezoelectric module d'_{12} and coupling factor k'_{12} are 7.9pC/N and 21.3%, respectively. These experimental results are in good agreement with the calculated data. As shown in Fig.2 the resonance spacing of (XYt)20° cut in the forty times more than (XYt) −20° cut. The investigation results of the temperature frequency characteristics will be shown at the conference.

$\varepsilon_{11}/\varepsilon_0$	16.6
$\varepsilon_{33}/\varepsilon_0$	25.2
d_{11} pC/N	4.07
d_{14} pC/N	13.25

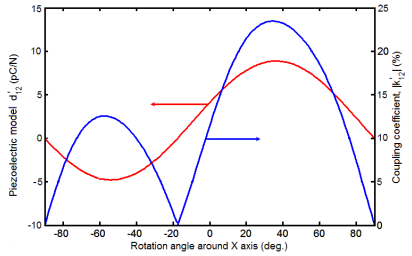

Fig.1 Dependence of piezoelectric koefficient d_{12} and coupling factor k_{12} vs. rotation angle around X axis.

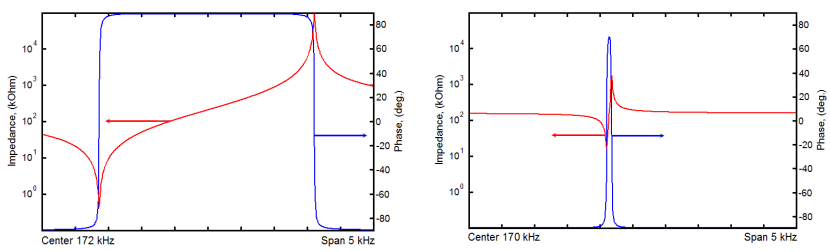

Fig.2 Impedance and phase characteristics of a) (XYt)20° and b) (XYt) - 20° rotated X-cuts.

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