MINIATURE TEMPERATURE-SENSITIVE STRIP-TYPE RESONATORS OF LANGASITE

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ABSTRACT

Some researches were carried out for making miniature piezoelectric resonance sensors of langasite with piezoelectric cells of strip type intended for operation within limits of wide temperature range.

INTRODUCTION

Langasite (chemical formula – $La_3Ga_5SiO_{14}$) is a promising material for applications in high-temperature transducers as it features high temperature ~1470°C of phase transformation. Some of the results of researches in the field of making miniature high-temperature sensors of langasite are presented to your attention in this paper.

THEORETICAL AND EXPERIMENTAL RESEARCHES

Crystallographic cut of YX1/α type and C operational mode of shear vibrations of thickness along direction of X-axis were applied in langasite sensors. Temperature-frequency characteristic of sensors with cut angle ~0° resembles quadratic parabola with extremum at temperature 0 – 5°C. At temperatures higher +150°C such sensors possesses sufficient magnitude of TCF_r-factor to measure temperature with a high accuracy. If decreasing or increasing cut angle α takes place, then the extremums of the parabola will shift into the field of positive or negative temperatures. Simultaneously, TCF_r-factor for certain angles ±α will increase; besides, the boundaries of operating range are expanded. Thus, it is possible to make sensors for measurement of high and low (cryogenic) temperatures.

Monotonicity of temperature-frequency characteristic of a sensor is affected detrimentally by side effects of unwanted oscillations; this is especially true in respect of B mode along the direction of Z-axis, as well as contour, bending and anharmonic oscillations. Extraneous oscillations springs up concurrently with oscillations of C operational mode. However, upon certain conditions relating to width b/thickness h proportion and length l of piezoelectric cell/length l_e of electrodes unwanted oscillations do not become excited. In this case, Q-quality increases. It becomes more then Q-quality of another form of piezoelectric cells. The value of Q-quality gets more with increase and decrease of cut angle α. Maybe, it is due to decrease of coefficient of electromechanical bond in langasite.

Temperature sensors were made such to be able to operate on working frequency ~5-10 MHz. Dimensions of piezoelectric cells were equal to 6.7x1.66x0.17 mm in order that they may be installed in miniature low-profile package with diameter of 3 mm and height of 8 mm. Design of piezoelectric cell and its amplitude-frequency responses are shown in fig. 1.2. Electrical characteristics are shown in table 1.

Operating performance of the sensor is well characterized by the following third-degree polynomial: $T = T_0 + K_1(F - F_0) + K_2(F-F_0)^2 + K_3(F-F_0)^3$, where T_0 is a reference value of temperature, F_0 is the value of frequency of the output signal, and K_1, K_2 and K_3 are the coefficients of temperature-frequency characteristic of the sensor.

Conclusion

Strip-Type resonators of langasite is a new temperature sensors of the piezoelectric resonance transducers.

Table 1. Characteristics of miniature langasite sensor.

F_r (kHz)	dF_{ar}, %	Q factor	R_1, Ohms	L_1, H	C_1, pF	C_0, pF	TCF_r, Hz/^oC (-10-+400 ^oC)	P_r, mcW
8900	0,06	43000	24	0,019	0,017	12,89	>150	~ 180
9000	0,08	32000	28	0,016	0,02	12,74		
10700	0,06	26000	33	0,013	0,017	14,76		

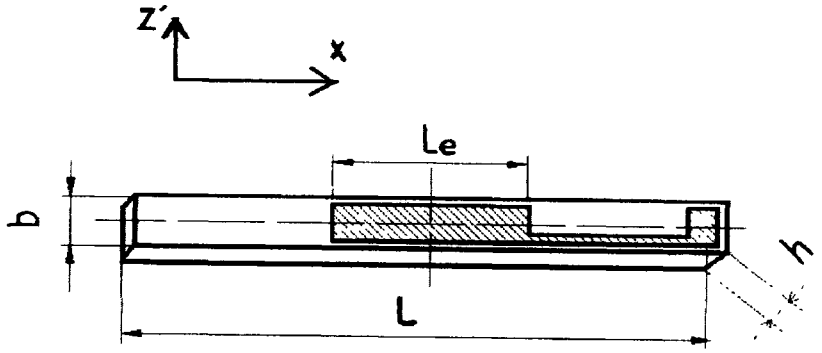

Fig.1. Desing of temperature sensor

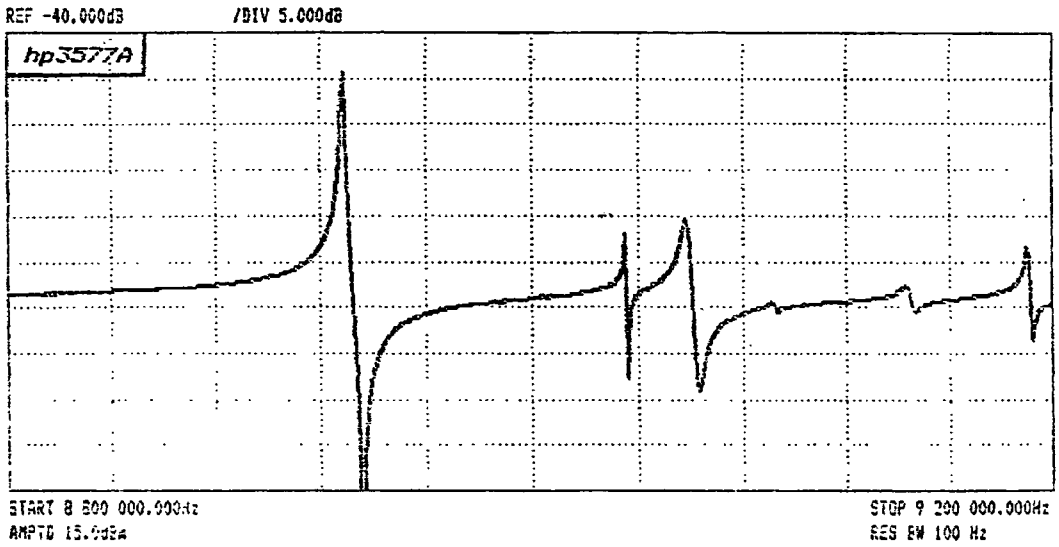

Fig.2. Amplitude-frequency responses of the sensor