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LETTER

Hydrophone Figure of Merit

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The potential of a number of hydrophone sensor materials is assessed by considering the sensitivity requirement and various noise contributions in the design of a hydrophone element. Noises originating from the loss tangent and pyroelectricity of the material can be serious factors. By considering the free-field voltage sensitivity and a proposed figure of merit $g_h d_h/\tan\delta$, it is shown that composites and glass ceramics are the more promising candidates for new sensor applications. The self-noise factors can be minimized by designing sensor materials that have large $g_h t$ and low $\tan\delta$ values. Pyroelectric noises can also be greatly reduced by appropriate composite designs.

For a crystal belonging to one of the piezoelectric classes, there is no guarantee that the crystal in actual measurements will display the piezoelectricity in all the stress conditions. In a particular stress environment, piezoelectric effects are permissible for some piezoelectric crystals. For a crystal used as a stress sensor, the change in polarization, ΔP_s, (or charge, ΔQ, developed on the per unit surface area of a sensor) is given by[1]

$$\Delta P_i = \frac{\Delta Q_i}{A} = \frac{d_{ij}\Delta\sigma_j}{d_{ij}} \quad (i = 1, 2; 3 \text{ and } j = 1\text{–}6), \tag{1}$$

where A is the area and d_{ij} are the piezoelectric coefficients of the sensing element. For a hydrostatic stress environment ($\sigma_1 = \sigma_2 = \sigma_3 = -P_h$, $\sigma_4 = \sigma_5 = \sigma_6 = 0$)

$$\Delta Q_i = d_{i(h)}\Delta p_h A. \tag{2}$$