

14. Study on High Dielectric Constant Ceramics. (XII) BaTiO₃ Ceramic Vibrator as the Underwater Sound Transmitter and Receiver

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When an electric field is applied to a BaTiO₃ ceramics, the elongation in the direction of electric field is theoretically twice the contraction in the direction perpendicular to the field. Moreover, the contraction is the indirect effect of the elongation and so is very much influenced by the internal conditions of the ceramics, so that practically the contraction is approximately equal or less than 1/3 of the elongation. From these reasons, when the ceramic substance is to be used as vibrator elements, it is desirable to utilize the mode of vibration in the direction of electric field, that is the thickness vibration of the plate.

But as an underwater sound transmitter, the resonant frequency should be restricted under 50 K.C. from the view point of attenuation of supersonic wave when it propagates in the water, and so, if we want a ceramic plate having resonant frequency of 50 K.C., about 5 cm thickness should be required. These plates are not only difficult to obtain, but inconvenient to use, because higher voltage should be applied between electrodes.

We tried, for these reasons, to develop the Langevin type of transducer using BaTiO₃ ceramic plate in place of quartz crystal plates. On both surfaces of the ceramic disk of 3-5 mm thickness and of 55-70 mm diameter, iron or brass cylinders were fixed with suitable method, and between the two metal cylinders was applied a D.C. voltage corresponding to 20 KV/cm for several hours.

As the dielectric loss angle of the ordinary BaTiO₃ ceramics is about 0.02, a very good efficiency can be expected about these vibrators. According to our experiments, for example, a value of 95% of the electro-mechanical efficiency and 88% of the mechano-acoustic efficiency and 84% of total efficiency could be obtained.

There were found generally more than one resonant frequency in these vibrators, one of which seemed to correspond to the thickness mode and the other the radial mode. And from our experimental results it could be concluded that there existed an evident phenomenon of coupling between the thickness mode and the radial mode.

These vibrators were examined successfully under practical use as transmitter and receiver of depth-sounder on the sea. These depth-sounder caught the echoes from the bottom of the sea about 150 meter deep and from every fish in the sea on Braun tube oscillograph.