converted to rotating angle of mirror and magnified as the movement of scale.

$BaTiO_3$ ceramics expand in the direction of applied field and contract in all directions at right angle to the applied field. To measure the coefficient for the lateral contraction, a cylindrical ceramic, of which both inner and outer surfaces are silver-plated, was used.

The amount of contraction increases with applied biasing voltage and it is found that the total decrease in length is about 1×10^{-4} up to a voltage gradient of 20,000 V/cm. The magnitude of electrostriction is ihfluenced not only by field intensity but the time of exposure to field. The effect of time comes out very gradually and it requires $10^2\sim10^5$ seconds to attain to the saturated value. The lower the field intensity drops, the longer the time becomes. When field is reduced to zero, there remains some residual striction, the magnitude of which is also affected by field intensity and time of exposure to field.

$BaTiO_3$ ceramic, that has been exposed to D. C. biasing field and has some residual striction, shows piezoelectric effect. We examined the relations between the piezoelectric sensitivity and applied field intensity or time of exposure to field, and got a result similar to that regarding electrostrictive effect. From our experimental results, it seems that the piezoelectric sensitivity of such materials as mentioned above is proportional of the residual striction remained after removal of field.

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19. Study on High Dielectric Constant Ceramics. (IV)

Electromechanical Vibration of $BaTiO_3$ Ceramics.

Kiyoshi Abe and *Tetsuro Tanaka.*

$BaTiO_3$ ceramic which has been exposed to D. C. biasing field, has some residual polarization after the field is removed. Such material has piezoelectric properties similar to those of quartz or Rochelle salt. If we examine the frequency characteristic of such polarized ceramic, we can find a resonance spectrum which is attributed to a piezoelectric effect. An experimental study was held in order to know the behavior of such resonance and to derive the frequency constants of these vibrations. About 20 specimens consisted of $BaTiO_3$ ceramics were prepared, half of these were formed like strips and another half rectangular plates. The polarizing field strength was 10,000 V/cm and the time of exposure was half an hour. Using these specimens, the resonant frequencies of longitudinal length mode and thickness mode were measured. The plots of $1/l$ (l is length of strip) and $1/t$ (t is thickness of plate) versus resonant frequencies indicate that these relations satisfy fairly well a linear relation, and it was found that the frequency constant is 225 K. C.-cm for the longitudinal length mode, and 255 K. C.-cm for the thickness mode. Employing the following equations, we can calculate the elastic constant E_l and E_t for the length and thickness direction respectively.

$$f=\frac{1}{2l}\sqrt{\frac{E_l}{\rho}}, \qquad f=\frac{1}{2t}\sqrt{\frac{E_t}{\rho}}$$

where ρ is density and if $\rho=5,5$ is used,

$$E_l=1,12\times10^{12}\ \text{dynes/cm}^2$$

$$E_t=1,42\times10^{12}\ \text{dynes/cm}^2.$$

The resonant frequency versus temperature curve, we obtained, indicates that the variation of resonant frequency is very small in the temperature range between room temperature and 60°C.

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20. Study on High Dielectric Constant Ceramics. (V)

$BaTiO_3$ Ceramics for Consenser Materials.

Kiyoshi Abe and *Tetsuro Tanaka.*

As the dielectric constant versus temperature curve of $BaTiO_3$ ceramics is comparetively flat at about room temperature, $BaTiO_3$ ceramics are useful as a condenser material. In special case, when the temperature coefficient is not so serious matter and very high dielectric constant is desired, such ceramics that have Curie point near room temperature are used. We previously experimented that in the solid solution of $BaTiO_3$ and $SrTiO_3$, the Curie point is shifted to lower temperature approximately in proportion to the amount of $SrTiO_3$, and the mixture containing 25% $SrTiO_3$ has Curie point at about room temperature. Recently, we developed these experiments and [studied on some solutions such as (Ba–Sr–Mg) TiO_3 or (Br–Sr–Pb) TiO_3 with various compositions.] The ratio of Ba : Sr is chosen 10 : 0, 9 : 1, 8 : 2, 7 : 3 etc., and to these mixture Mg or Pb is added from zero to 50 percent.

Addition of small quantity of $MgTiO_3$ shifted the Curie point to lower temperature, while large amount of $MgTiO_3$ only decreased the dielectric constant without any remarkable influence on the shifting of Curie point. For example, a mixture of $BaTiO_3$ 81%, $SrTiO_3$ 9%, $MgTiO_3$ 10%, has dielectric constant of about 4,000 and loss angle of about 50×10^{-4} at Curie point near 40°C. The addition of $PbTiO_3$ generally shifted the Curie point to higher temperature in proportion to the quantity of $PbTiO_3$, and addition of large amount of it reduced the dielectric constant. For example, a mixture of $BaTiO_3$ 72%, $SrTiO_3$ 18%, $PbTiO_3$ 10%, has dielectric constant of about 4500 and loss angle of about 150×10^{-4} at Curie point near 40°C. The characteristics of dielectric constant versus temperature are somewhat flattend by adding $MgTiO_3$ or $PbTiO_3$ in both cases. The firing of such ceramics is considerably easy as compared with that of pure $BaTiO_3$ ceramics.