The permittivity of TGS was measured as a function of temperature, crystal thickness, and electrode material. The conductivity of the electrode material was influenced by the switching process in the ferroelectric substrate. This effect was studied in order to obtain information on the surface layer of TGS. A model is proposed which approximately explains the measurements.

**INTRODUCTION**

The surface of a crystal is more or less disturbed because normal bonds cannot be formed there and the crystal properties at the surface are thereby influenced. This must be particularly evident in ferroelectrics because ferroelectricity is a structure-sensitive property of crystals. Research on surface layers in BaTiO₃ has been done for a long time [1-10]. It seemed of interest to look for surface layer effects in other ferroelectrics. Because of its very high relative permittivity at the Curie point, TGS seemed reasonable to examine more closely the permittivity as a function of crystal thickness and electrode material. From such measurements the capacitance of the supposed surface layer may be estimated. This problem has already been discussed in [11] and [12]. Considerable electrical fields occur in the mentioned layers caused by very high polarization charges at the boundary between layer and bulk. These fields lead to an injection of charge carriers from the evaporated electrode into the crystal. In this way, the specific conductivity of the electrode material is changed. For this reason, the resistance of the electrode as a function of temperature, polarization and time was examined.

**ON CRYSTAL THICKNESS, TEMPERATURE AND ELECTRODE MATERIAL DEPENDENCE OF THE PERMITTIVITY**

A crystal with surface layers can be represented as surface and bulk capacitances in series (Fig. 1). The measured permittivity of the whole crystal can be obtained as:

\[
\frac{1}{\varepsilon_{\text{exp}}} = \frac{1}{\varepsilon_B} + \frac{2d_L}{\varepsilon_L} \cdot \frac{1}{d}
\]

Fig. 1. Schematic graph of a crystal with surface layers. \(d_L\); thickness of the surface layer, \(d\); thickness of the whole crystal (\(2d_L \ll d\)), \(\varepsilon_L, \varepsilon_B\); layer and bulk permittivity resp., \(E_L, E_B\); electrical field in the layer and bulk resp.
On surface layer effects in TGS with evaporated semiconductor electrodes

It is easy to realize that from variations of the crystal thickness and from simultaneous measurements of the permittivity conclusions may be drawn regarding the magnitude of \(2d_L/e_L\), i.e. the capacitance of the surface layer. Because of the high permittivity of TGS at the Curie point the two terms of Eq. (1) have approximately the same order of magnitude even at usual crystal thicknesses. Thus the effect can be measured quite easily. The measurements were made with evaporated Au- and Te-electrodes at 1 kHz.

Fig. 2. \(1/e_{\exp}\) as a function of reciprocal crystal thickness for various electrodes. 

The Curie point of our TGS-specimens was between 49.08° and 49.12 °C; the thickness varied from 1.20 to 0.25 mm; the relative humidity of the atmosphere around the crystal was kept very small by concentrated sulphuric acid. Detailed measured values are given in Fig. 2. The linear dependence (cf. Eq. (1)) of \(1/e_{\exp}\) on \(1/d\) was only observed with etched specimens, but not with polished ones. For comparison, the values of [11] and [12] are also shown in Fig. 2. It is interesting that the term \(2d_L/e_L\) for Au is larger than for Ag and for Ag is again larger than for Te. Apparently the crystal surface is destroyed by evaporating the electrode material on the crystal in high vacuum. In this way the crystal surface is assumed to lose its ferroelectric properties. This conclusion is confirmed from the correlation of \(2d_L/e_L\) and the evaporation temperature of the electrode material shown in Fig. 3. The evaporation temperature was taken to be the temperature at which the vapour pressure of different electrode materials reaches \(10^{-2}\) mm Hg.

Fig. 3. \(2d_L/e_L\) as a function of the evaporation temperature of the electrode material.