8-8

# Characterization of $Pb_5Ge_3O_{11}$ as Page Composer Material

Yoshio ITOH, Tomoaki YAMADA, Hiroshi IWASAKI and Shintaro MIYAZAWA
Musashino Electrical Cmmunication Laboratory, Nippon Telegraph and Telephone Public Corporation, Musashino-shi, Tokyo, Japan

Lead germanate ($Pb_5Ge_3O_{11}$) is ferroelectric and optically active below its Curie point at 177°C[1,2]. Since the signs of its optical rotatory power (5°35'/mm at 6328A) can be switched by the reversal of the spontaneous polarization[3] without inducing any macroscopic strain, the crystal is a promising candidate as the material for electro-optic devices such as a page composer and a pattern display element. In this paper the process of the polarization reversal is analyzed and some performance characteristics as a page composer is reported.

The c-plates were cut from the poled crystal grown by the Czochralski pulling method and polished optically flat. Thin gold films were evaporated as semi-transparent electrodes and the ferroelectric domain motions could be directly observed under the polarizing microscope by applying the electric field along the c-axis[4].

With a high voltage pulse generator the electric field dependence of the nucleation rate of the antiparallel domains, c, and the sidewise velocity of the domain wall motion, v, could be separately measured, and both were found to obey the exponential laws expressed as $c=c_\infty e^{-\alpha/E}$ and $v=v_\infty e^{-\beta/E}$. However, they showed different field dependence above and below 4.5KV/cm. The activation fields were obtained as $\alpha$=80KV/cm and $\beta$=50KV/cm for the field above 4.5KV/cm and $\alpha$=10KV/cm and $\beta$=13KV/cm for that below 4.5KV/cm.

The field dependence of the total switching time $t_s$ was also measured and the results are shown in Fig.1. As an example $t_s$ is about 30μsec at 10KV/cm. From this figure the relevant activation field is obtained as 61KV/cm above 4.5KV/cm and this value agrees with the calculated one of 60KV/cm using the relation[5], $1/t_s \propto (cv^2)^{1/3}$. For the field below 4.5KV/cm the activation field was measured as 18KV/cm and is a little larger than the calculated one of 12KV/cm.

This crystal has not the definite threshold for the polarization reversal when driven with d.c. electric field. It was found, however, that if driven with the pulsed electric fields, there exists threshold in the pulse width, which depends on the pulse height. Because of this characteristic property $Pb_5Ge_3O_{11}$ is particularly promising as the page composer material.

Page composers were constructed with c-plates of dimensions up to 5×5mm$^2$. The stripes of gold films were evaporated onto the opposite faces to form matrix type electrodes. Applying electric pulses with appropriate voltage and width to the selected row and column, the part between them could be switched as a light valve due to the d-l conversion in this region. A photograph of the page composer is shown in Fig.2. This represents a part of 16×16 bit matrix and all the valves are "on" state. The thickness of this plate is 1.3mm, the width of gold electrodes is 0.1mm, and the distance between adjacent electrodes is 0.2mm. The applied voltage is 800V with the pulse of 50 $\mu$sec.

The contrast ratio depends on the thickness of the plates. The plate of 1mm thickness gave the contrast ratio of 40:1. The higher ratio can be achieved with thicker plates, but the electric field for domain switching becomes higher.

It was confirmed that the bit density of more than 25/mm$^2$ could be achieved for the plate of thickness of 1.9mm.

The other important properties as a page composer, such as the effect of oblique incidence of light beam will be also reported.

References


1) K.Sugii, H.Iwasaki and M.Miyazawa, Materials Res. Bull. 18(1971) 503

2) H.Iwasaki, K.Sugii, T.Yamada and N.Niizeki, Appl. Phys. Letters 18(1971) 444

3) H.Iwasaki, K.Sugii, N.Niizeki and H.Toyoda, Ferroelectrics 3(1972) 157

4) J.P.Dougherty, E.Sawaguchi and L.E.Cross, Appl. Phys. Letters 20(1972) 364

5) E.Fatuzzo and W.J.Merz, Ferroelectricity (North-Holland 1967)


Fig. 1

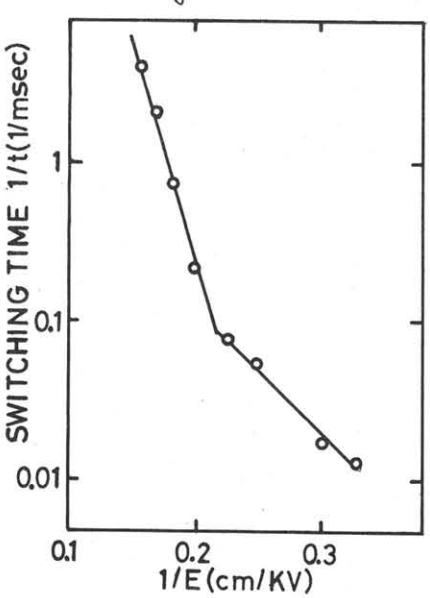


Fig. 2