Digest of Tech. Papers The 10th Conf. on Solid State Devices, Tokyo

B－7－3 New Electro-Optical Effects in Ferroelectric Liquid Crystals

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We have studied electrical properties of a series of p-alkoxy benzylidene-p'-amino-2-methylbutyl-cinnamate and typical ferroelectric behaviours such as D-E hysteresis and Curie-Weiss like law were found in the smectic-C and -H phases of the compounds1) with alkoxy chain length n longer than 6 (DOBAMBC:p-decyloxybenzylidene-p'-amino 2-methylbutyl-cinnamate,n=10; DDOBAMBC,n=12; TDOBAMBC,n=14; OOBAMBC,n=8; HOBAMBC,n=6). In this paper, new electro-optical effects which are characteristic for the ferroelectric liquid crystal will be reported.

The samples were sandwitched between nesa coated glass plates. Homogeneous alignment of liquid crystal molecules was achieved by the oblique evaporation of SiO on the glass plates beforehand. The transmission intensity I of He-Ne laser through this liquid crystal cell and its change with voltage application were monitored by a photomultiplier.

Transmission intensity in the ferroelectric phase under crossed polarizer decreases a little by applying low voltage. With the application of higher voltage above some threshold V_c (for example, 15V/cm in the cell of 30μm thickness at 72°C), however, the transmission once decreases slightly at the instant of the voltage application and then increases remarkably. Such effects are not observed in the smectic-A (non-ferroelectric) phase. Voltage dependence of I normalized to the transmission intensity I_0 under no applied voltage at various temperatures is shown in Fig.1. At higher fields, the transmission intensity decreases slightly again. The rise time of the initial small decrease of I is much faster than that of the main increase of the transmission. The later also becomes shorter with increasing voltage above V_c as shown in Fig.2. The periodic parallel stripes separated by several microns are observed by an optical microscope with crossed polarizers in the smectic-C phase under no applied voltage, which may be originated from the periodic change of the tilt angle of the molecules from a layer to a next layer. With applying voltage beyond V_c, this periodic stripes disappeared. Therefore, the increase of the transmission intensity with voltage application may be due to the decrease of the light scattering by the disappearance of the periodic lattice. Namely this phenomenon is due to the collective reorientation of the ferroelectric domains by the electric field. In smectic-A phase such stripe was not observed, which is consistent with the lack of similar electro-optical effect in this phase. Under the crossed polarizer, I decrease again slightly at high enough fields. But it does not due to the disturbance of the molecular alignment in the layer by the ionic current (DSM), because under the condition parallel polarizers and non-polarizer, the transmission intensity still increases contrary to the case of crossed polarizers as shown in Fig.3

As already mentioned, D-E characteristic in this liquid crystal meaured by a Sawyer-Tower method shows hysteresis and it depends on the frequency of the applied field. Figure 4 shows the dielectric constant as a function of the bias d.c. voltage (namely differential curve of d.c. D-E hysteresis). Correspondingly to this hysteresis, the observed electro-optical effect also shows hysteresis as shown in Fig.5.

Decay time of the main increase of the transmission after the removal of the applied voltage becomes longer with decreasing temperature. At high temperatures it can be used as one sort of display element just as DSM and TN modes of nematic liquid crystal. At intermediate temperatures it can be used as dynamic optical memory. AT low temperature and in the thin sample in which decay time is long enough (> day), it can be used as optical memory element. Detailed characteristics of these optical effects are studied as functions of the molecular structure (chain length), temperature, sample thickness and the frequency of the applied field.

Reference. 1) K.Yoshino, T.Uemoto and Y.Inuishi ; Japan. J. Appl. Phys. 16 (1977) 571

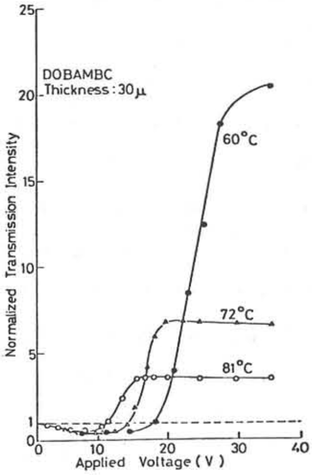

Fig.1

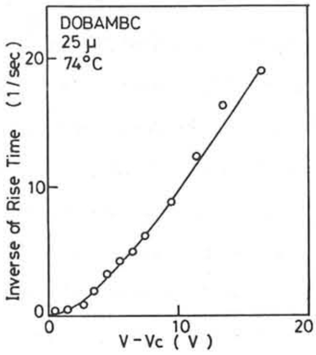

Fig.2

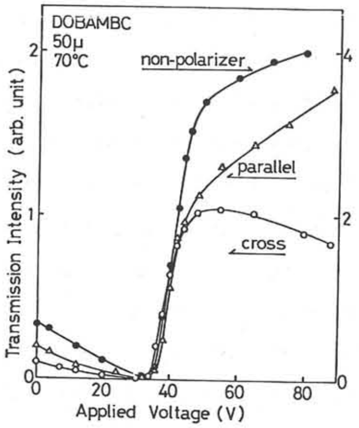

Fig.3

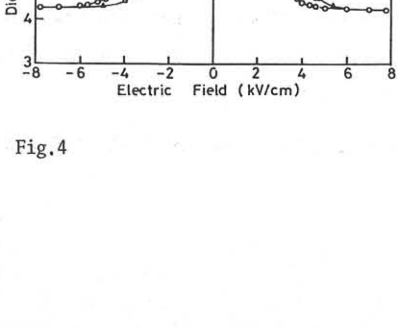

Fig.4

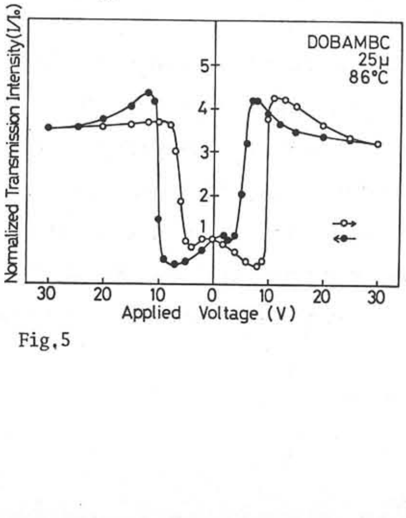

Fig.5