Investigation of thin optically anisotropic ZnO films placed in a strong uniform magnetic field

E.F. Venger[1], A.I. Ievtushenko[2], L.Yu. Melnichuk[2], O.V. Melnichuk[2]
[1]*V. Lashkaryov Institute of Semiconductor Physics, NAS of Ukraine, Kyiv, Ukraine*
[2]*Mykola Gogol State University, Nizhyn, Ukraine*
mov310@mail.ru

***Abstract* — We present the results of IR spectroscopy and attenuated total reflection (ATR) investigations of the properties of polar optically anisotropic ZnO films on hexagonal 6H-SiC single crystals. The ATR and IR reflection spectra were taken using a spectrophotometer ИКС-31 with an attachment ИПО-22 and НПВО-2, in the actual frequency region for ZnO film (400–600 cm^{-1}) and 6H-SiC substrate (788–970 cm^{-1}).**

***Index Terms* — IR spectroscopy, attenuated total reflection, ZnO films on hexagonal 6H-SiC single crystals.**

I. INTRODUCTION

A mathematical model has been developed, with additive and phenomenological contribution from oscillators to the permittivity of optically anisotropic undoped and heavily doped ZnO films (thickness up to 1 μm) deposited onto a semi-infinite substrate of hexagonal 6H-SiC single crystal. Such a two-layer system was subjected to action of a strong uniform magnetic field. This made it possible to simulate the ATR and IR reflection spectra in the region of residual rays of the above semiconductors.

It was shown, for the first time, that it is possible to excite phonon and plasmon-phonon surface polaritons (SPs) in thin ZnO films on optically anisotropic silicon carbide (polytype 6H) single crystals located in a strong uniform magnetic field, at mutually orthogonal orientations of substrate optical axis *C*, wave vector *K* and magnetic field $\vec{H}$: $C \square x$, $K \square C$, $xy \square C$; $C \square z$, $K \perp C$, $xy \perp C$; $C \square y$, $K \perp C$, $xy \square C$, $\vec{H} \perp K$, $\vec{H} \square y$.

We found that optical anisotropy of thin ZnO films and interrelation between magnetoplasmons and low-frequency optical phonons in 6H-SiC lead to appearance of new features in the IR reflection spectra as well as phonon and plasmon-phonon SPs spectra that differ essentially from those in cubic semiconductors. These are doubling of cutoff and resonance frequencies, appearance of new transparency and opacity regions in the external reflectance spectra of substrate etc.

It was shown that, in the residual rays region of the 6H-SiC single crystals subjected to action of a strong uniform magnetic field, up to four resonance and cutoff frequencies may be registered. They depend on the magnetic field strength and increase monotonically. For the first time, new dispersion branches and their splitting in the high-frequency spectral region were detected with the ATR technique, anisotropy of damping coefficients was studied etc.

The experimental ATR and IR reflection spectra of ZnO films on single-crystalline 6H-SiC substrates subjected to action of a strong uniform magnetic field were taken. We studied the main SP features (dispersion curves and damping coefficient) for thin ZnO films located in a strong uniform magnetic field. The effect of uniform magnetic field on the properties of SPs in 6H-SiC was investigated.

II. CONCLUSION

It is shown that nondestructive optical diagnostics of thin ZnO films on single-crystalline 6H-SiC substrates with ATR and IR spectroscopy enables one to get data on the optical and electrophysical properties of polar optically anisotropic two-layer structures (charge carrier mobility, conductivity, refractive index etc.).