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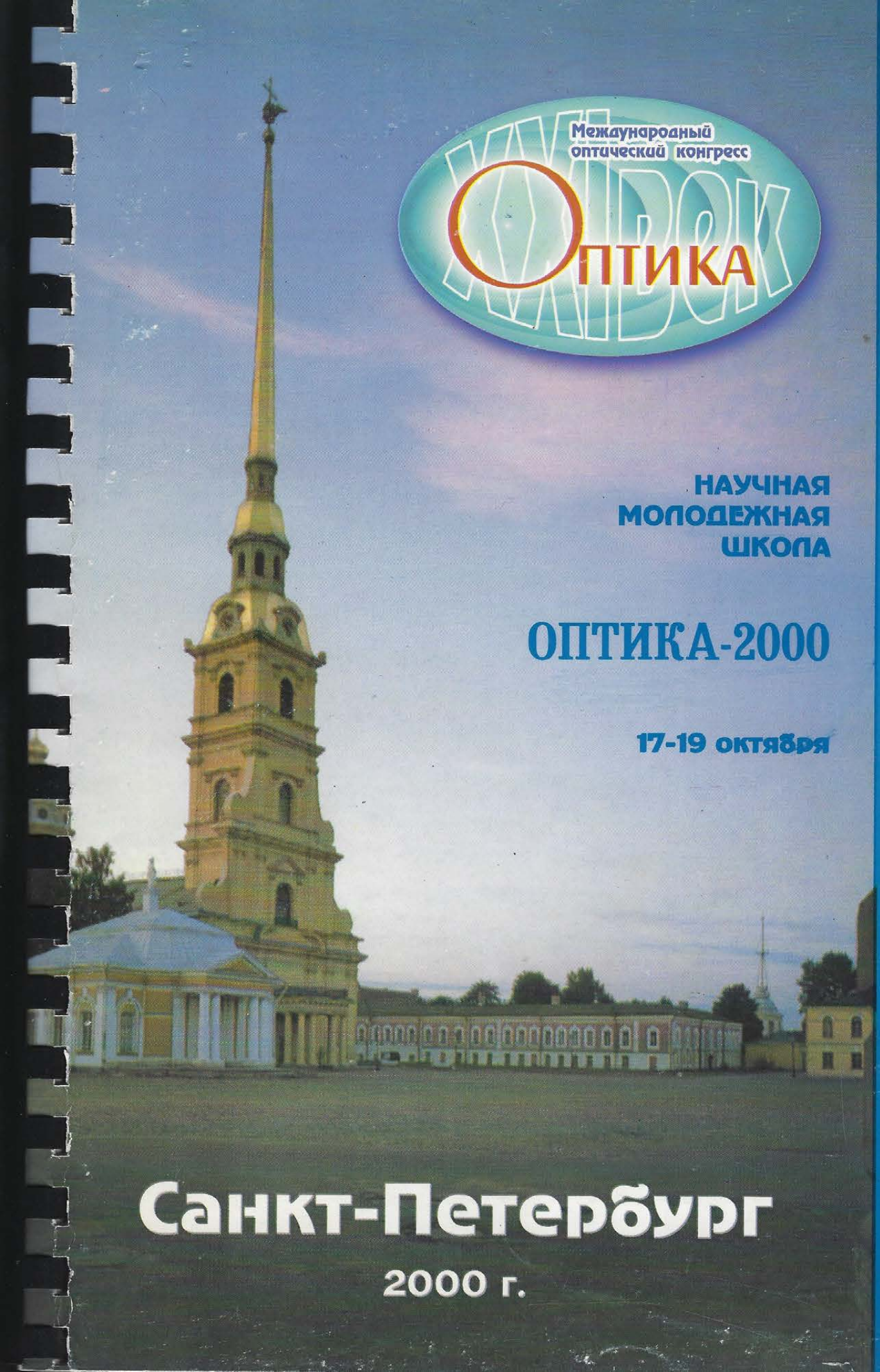

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PHOTOLUMINESCENCE AND MAGNETO-OPTICAL CHARACTERIZATION OF A NOVEL DIAMOND-LIKE FERROMAGNETIC SEMICONDUCTOR $CdMnGeP_2$

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Topic: Coherent processes of light interaction with substance.

Optical and magneto-optical properties of the novel ternary compound $Cd_{1-x}Mn_xGeP_2$ that reveals strong ferromagnetic behavior at T = 300 K have been presented. Photoluminescence and magneto-optical Kerr ellipticity spectra were measured in the range of 1~4 eV.

Modern methods of magneto-optical (MO) recording on MO disks and potentialities of speeding up the information exchange due to an electron spin of carriers stimulate the search in new magnetic materials.[1, 2] The main requirement is to combine in one advantages of a semiconductor with well-controlled electronic properties and a ferromagnet with non-volatile strong hysteresis. Recent years the best success was achieved in Ga-Mn-As ferromagnetic semiconducting system. The realized temperature, when the ferromagnetic effect does not volatile, to date is $T_C \leq 110$ K. However, practical applications insist on higher temperatures, for example, room temperature. This paper describes optical and magneto-optical properties of the newly grown diamond-like semiconductor material in Mn-$CdGeP_2$ quaternary system, which reveals the room temperature ferromagnetism.

As a host material we used the oriented chalcopyrite crystal $CdGeP_2$ and have converted its part into a new magnetic phase $CdMnGeP_2$.[3, 4] Thin Mn layers of 200 Å and 300 Å thickness were deposited on $CdGeP_2$ crystal in a MBE chamber from a Knudsen cell, then the thermal treatment was carried out at about 500°C for 30 minutes. The RHEED and XRD analysis exhibit that the $CdMnGeP_2$ has almost the same crystal structure as of the host crystal. The Mn concentration in the converted area (~0.5 μm) is excess 20% confirmed by EDX techniques. The magnetization measurements were carried out for the first time in this ternary chalcopyrite family: the distinct hysteresis loop was measured at room temperature, Curie temperature is found to be of $T_C = 320$ K. The SEM and RHEED patterns indicate some crystallite orientation in the upper film of a texture type.

Figure 1 presents photoluminescence (PL) spectra of the starting crystal and two different samples $CdMnGeP_2$ after the first and the second deposition of Mn-layer. The main spectral maximum shifts from near IR to near UV range indicating an increase of the energy gap of the new material. The E_g value is approximately doubled from 1.83 eV ($CdGeP_2$) to ≈3.5 eV ($CdMnGeP_2$).

Figure 2 shows the magneto-optical Kerr ellipticity spectrum of $CdMnGeP_2$ layer taken at room temperature. The MO structure is extended over the photon energy range from 1.3 eV to 4.0 eV and reaches the maximal amplitude of 0.14° at around the E_g value of $CdGeP_2$ substrate. The high energy wing is structured with spectral features at 2.7 eV and 3.4 eV. These MO peaks agree with PL peaks in Fig. 1 for the ferromagnetic phase and answer the electron transitions optically and magneto-optically active at temperatures 20~300 K. Taking into consideration single crystallinity of the substrate and grown magnetic layers with the similar chalcopyrite structure, one can conclude that MO structures in Fig. 2 belong to the new ferromagnetic phase with specific features in the visible and near UV range.

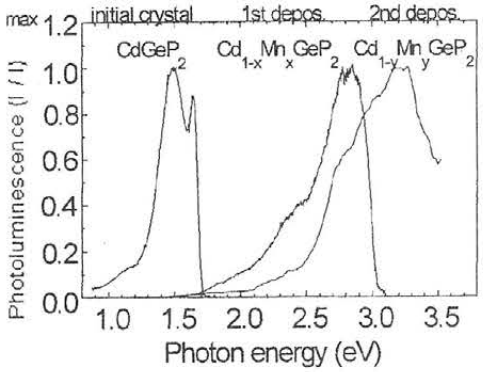

Fig. 1. PL spectra at T=20 K of $CdGeP_2$ crystal and $CdMnGeP_2$ layers with Mn concentration x<y.

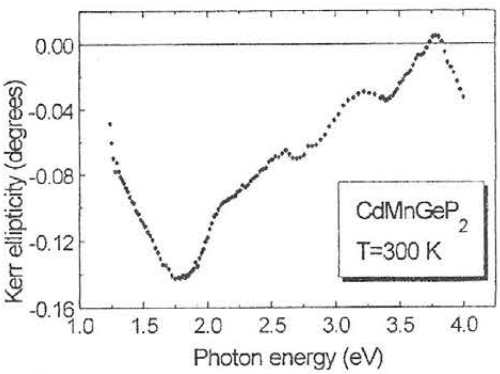

Fig. 2. MO Kerr ellipticity spectrum at T=300 K of $Cd_{1-y}Mn_yGeP_2$ layer.

Using the near-field microscope in atomic force and magnetic force modes, we recorded AFM and MFM images (8 μm × 8 μm) of the surface of the grown layer in the remanence magnetization state at T = 300 K. The MFM image clearly shows the stripe-shaped magnetic domains, the width of 1 μm that is considerably large than the size of the texture (0.1~0.2 μm), supporting strong magnetic behavior of the novel diamond-like $CdMnGeP_2$ material.

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