Terahertz to UV Generalized Magnetooptic ellipsometry on ZnMnSe: Giant Kerr effect, band-to-band transitions, and charge transport parameters

UNIVERSITY OF NEBRASKA-LINCOLN

ThP.126

M. Saenger[1,*], B. Daniel[2], M. Hetterich[2], T. Hofmann[1], and M. Schubert[1]

[1] Department of Electrical Engineering and Nebraska Center for Materials and Nanoscience, University of Nebraska-Lincoln, U.S.A.
[2] Institut für Angewndte Physik and Center for Functional Nanostructures (CFN), University of Karlsruhe, Germany

*saenger@engr.unl.edu

ellipsometry.unl.edu

Our message

I. Kerr rotation in paramagnetic ZnMnSe.

II. Optical anisotropy found in ZnMnSe, probably due to in-plane strain, or atomic ordering.

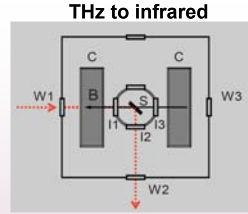
III. Zeeman splitting of the conduction bands as function of Mn content.

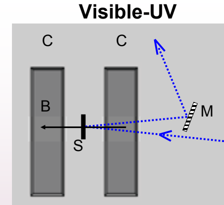
IV. Free charge charge carrier parameters of ZnMnSe.

Experiment and model

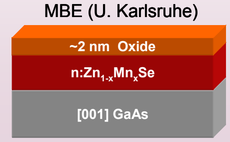
- ✓ Magneto-Optic Generalized Ellipsometry (MOGE) at RT on ZnSe and $Zn_{1-x}Mn_xSe$ (x=0, 0.13, 0.28) in the spectral range from 70 to 650 cm^{-1} and from 1.2 to 3.4 eV.
- ✓ Isotropic model dielectric function (MDF) for ZnSe, and ZnMnSe (Phys. Rev. B **70**, 04513, (2004))
- ✓ Observation of in-plane anisotropy in ZnMnSe (in absence of a magnetic field)
- ✓ Anisotropic MDF of ZnMnSe
- ✓ MOGE (Kerr rotation) measurements of ZnSe and $Zn_{1-x}Mn_xSe$ (x=0, 0.13, 0.28)
- ✓ MDF for Zeeman splitting in ZnMnSe (magnetic field induced birefringence)
- ✓ Charge transport parameters of low chlorine doped ZnMnSe

Setup





MBE (U. Karlsruhe)

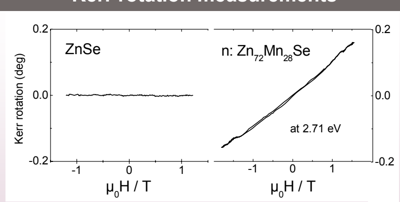


low chlorine doped $Zn_{1-x}Mn_xSe$

x=0, 0.13, 0.28

Experimental results

Kerr rotation measurements



MOGE measurements in quasi-Kerr configuration for ZnSe, and $Zn_{72}Mn_{28}Se$. The $Zn_{72}Mn_{28}Se$ sample shows a paramagnetic response for a photon energy corresponding to the band-to-band transition, while in ZnSe no Kerr rotation is detected.

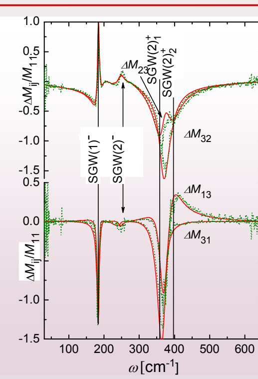
Free charge carrier parameters

Γ-Point CB effective mass

	$N[10^{17}cm^{-3}]$	$m^*[m_0]$	$\mu[10^2\ cm^2/(Vs)]$
GaAs-sub.	10.5(1)	0.071(1)	20.5(1)
ZnMnSe	4.9(2)	0.086(2)	3.0(2)

corresponds to kp-calculations of the Γ-Point CB effective mass for $Zn_{0.87}Mn_{0.13}Se$

Hofmann, Schade, Schubert, et al., Appl. Phys. Lett. 88, 042105 (2006)



Dielectric response

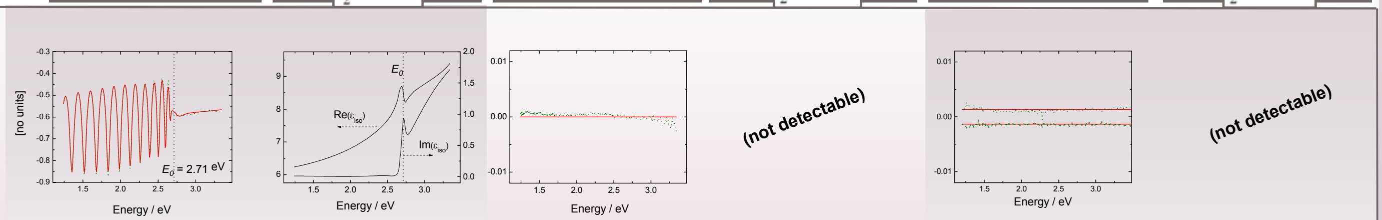
	Isotropic		In-plane birefringence		Magnetic induced birefringence

$$\varepsilon(\omega) = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \frac{1}{2}(\varepsilon_{\parallel} + \varepsilon_{\perp}) + \begin{pmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 0 \end{pmatrix} \frac{1}{2}(\varepsilon_{\parallel} - \varepsilon_{\perp}) + \begin{pmatrix} 0 & i & 0 \\ -i & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} \frac{1}{2}(\varepsilon_{+} - \varepsilon_{-})$$

M_{12} | $\frac{1}{2}(\varepsilon_{\parallel} + \varepsilon_{\perp})$ | M_{14} | $\frac{1}{2}(\varepsilon_{\parallel} - \varepsilon_{\perp})$ | M_{12} | $\frac{1}{2}(\varepsilon_{+} - \varepsilon_{-})$

Materials

ZnSe

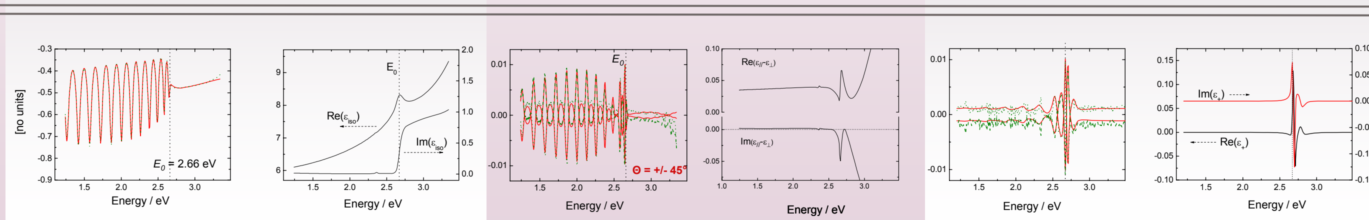


The real and imaginary parts of the isotropic dielectric function obtained from the best match analysis of the GE experimental data.

The Mueller matrix element M_{14} used to detect in-plane birefringence shows no signal in the studied spectral range.

No signal was detectable from the MOGE experiment as shown by the M_{23} and M_{32} elements.

$Zn_{72}Mn_{28}Se$



Same as above.

A significative difference between the parallel and perpendicular dielectric function was found for ZnMnSe.

12 meV conduction band splitting energy detected in ε_+ and ε_- at $\mu_0 H$ = 1.8 T.

4th International Conference on Spectroscopic Ellipsometry, Stockholm, June 11-15 2007

Funded by NSF withinin MRSEC Q-SPINS.