ZnMnTe/ZnMgTe nanowires studied by magneto-photoluminescence

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- Motivation & experimental
- CW measurements
- Polarization
- TR measurements
- summary
Motivation

Potential of DMS nanowires: DMS + shape anistropy:

- Magnetooptical switches
- Spin filters
- ...

What characterizes the system?

- Emission polarization performance in magnetic field
- Photoexcitation decay and relaxation channels
- ...

Our investigations:

- Polarization of emission
- PL dynamics in magnetic field
Optically active ZnMnTe/ZnMgTe core/shell nanowires (NWs):

- MBE Vapour-Liquid-Solid growth
Optically active ZnMnTe/ZnMgTe core/shell nanowires (NWs):

- MBE Vapour-Liquid-Solid growth
- Core/shell ~70/35 nm
- $x_{\text{Mn}}$ up to 4 %
Experimental Setup

- **Excitation**: 442 nm (cw) and 410 nm (pulsed) lasers, focused to $d = 3 \, \mu m$
- **Magnetic field up to 10 T**, temperature of 2 K
Excitation: 442 nm (cw) and 410 nm (pulsed) lasers, focused to $d = 3 \, \mu m$

Magnetic field up to 10 T, temperature of 2 K

Detection: CCD or a streak camera

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Luminescence: Following the single NW

Linewidth of single NW emission $\sim 2 - 5$ meV

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NW excitonic transition in magnetic field:

- **Energy**: redshift due to the Zeeman splitting
- **PL intensity**: increase up to 5x
- **Linewidth**: decrease (down to 60 %)
Emission in Magnetic Field

- Zeeman splitting
  \[ \Delta E(B) = E_s B_S \left( \frac{g_{\text{Mn}} \mu_B B}{kT_{\text{eff}}} \right) \]
  \[ E_s = \frac{1}{2}(N_0 \alpha - N_0 \beta)x_{\text{Mn}} S_0 \]
- fit yields \( E_s = 56 \text{ meV} \)
- \( \Rightarrow x_{\text{Mn}} = 3.6\% \)

\( T_{\text{eff}} = 5.7 \text{ K} \)
\( x_{\text{Mn}} = 3.6\% \)
Emission in Magnetic Field

PL Intensity enhancement:
- Brillouin – like dependence
- saturation at about $B = 3$ T

1. Zeeman splitting

$\Delta E(B) = E_s B S \left( \frac{g_{Mn} \mu_B B}{kT_{eff}} \right)$

$E_s = \frac{1}{2} (N_0 \alpha - N_0 \beta) x_{Mn} S_0$

- fit yields $E_s = 56$ meV
- $=> x_{Mn} = 3.6 %$

$T_{eff} = 5.7$ K

$x_{Mn} = 1.8 %$

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Emission in Magnetic Field

PL Intensity enhancement:
gradual quenching of non-radiative, spin–dependent recombination channel related to Mn ions

\[ \text{slope} = 1.13 \]

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Our NWs: High degree of LPD (av. 40 % at 0 T)

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Polarization in magnetic field

Linear Polarization Degree

polarization direction

Voigt: altered by magnetic field

Faraday: negligible impact of magnetic field

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Time resolved study of Photoluminescence

- ZnMnTe sample: Magnetic field induced exciton lifetime increase (up to 60% in 10 T)
- Saturation at $B = 3 - 4$ T

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Time resolved study of Photoluminescence

- Non-radiative processes inhibited
- consistency with cw measurements.

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**Time resolved study of Photoluminescence**

ZnTe sample:

- excitonic lifetime independent of the magnetic field
- Decay time – order of magnitude longer.

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Polarization and emission dynamics of optically active magnetic ZnMnTe/ZnMgTe nanowires determined

High degree of linear polarization due to anisotropic geometry of nanowire

Polarization of emission affected by magnetic field in Voigt configuration

cw and TR measurements: Spin dependent, non-radiative channel of photocreated carriers recombination quenched by magnetic field
Time resolved study of Photoluminescence

NW’s Excitonic Emission

Photon wavelength (nm)

Time (ns)

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Emission dynamics in magnetic field

LPD alters in Voigt configuration

Emission polarization direction

Projection on NW’s axis

$B = 0$

$B > 0$

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