

Projekt LIDER – stan na 10.2012

Jan Suffczyński

Kierunki badań

- Magnetoptyka (REF, MCD, MOKE, PL): (Ga,Mn)N i (Ga,Fe)N
- Opis oddziaływania wymiennego jon magnetyczny – nośnik w reżimie silnego sprzężenia
- Stałe wymiany jon-jon
- Kontrola stanu spinowego i ładunkowego Mn
- Ferromagnetyczne DMS

Półprzewodniki szerokoprzerwowe z nanoklasterami metalicznymi dla opto-elektroniki

Czas trwania: 2010 - 2013

Przedmiot badań : nanokompozyty azotkowe i tlenkowe, w tym **(Ga,Fe)N** i **(Zn,Co)O**

Główne kierunki:

- Efekty magnetoptyczne, np. efekt Kerra, Faradaya
- Plazmoniczne wzmocnienie efektów magnetoptycznych i emisji
- Fotoniczne wzmocnienie efektów magnetoptycznych
- Wpływ domieszkowania Fe na emisję złącz p-n na bazie GaN

Publikacje

- J. Suffczyński, A. Grois, W. Pacuski, A. Golnik, J. A. Gaj, A. Navarro-Quezada, B. Faina, T. Devillers, and A. Bonanni, *Effects of $s,p-d$ and $s-p$ exchange interactions probed by exciton magnetospectroscopy in $(Ga,Mn)N$* , [Physical Review B 83, 094421 \(2011\)](#).
- A. Bonanni, M. Sawicki, T. Devillers, W. Stefanowicz, B. Faina, Tian Li, T. E. Winkler, D. Sztenkiel, A. Navarro-Quezada, M. Rovezzi, R. Jakięła, A. Grois, M. Wegscheider, W. Jantsch, J. Suffczyński, F. D'Acapito, A. Meingast, G. Kothleitner, and T. Dietl, *Experimental probing of exchange interactions between localized spins in the dilute magnetic insulator $(Ga,Mn)N$* , [Physical Review B 84, 035206 \(2011\)](#).
- W. Pacuski, J. Suffczyński, P. Osewski, P. Kossacki, A. Golnik, J. A. Gaj, C. Deparis, C. Morhain, E. Chikoidze, Y. Dumont, D. Ferrand, J. Cibert, and T. Dietl, *Influence of $s,p-d$ and $s-p$ exchange couplings on exciton splitting in $Zn(1-x)Mn(x)O$* , [Physical Review B 84, 035214 \(2011\)](#).

Publikacje

- J. Papierska, J.-G. Rousset, W. Pacuski, P. Kossacki, A. Golnik, M. Nawrocki, J.A. Gaj, J. Suffczyński, I. Kowalik, W. Stefanowicz, M. Sawicki, T. Dietl, A. Navarro-Quezada, B. Faina, T. Li and A. Bonanni, *Magneto-optical properties of (Ga,Fe)N layers*, [Acta Physica Polonica A 120, 921 \(2011\)](#).
- Thibaut Devillers, Mauro Rovezzi, Nevill Gonzalez Szwacki, Sylwia Dobkowska, Wiktor Stefanowicz, Dariusz Sztenkiel, Andreas Grois, Jan Suffczyński, Andrea Navarro-Quezada, Bogdan Faina, Tian Li, Pieter Glatzel, Francesco d'Acapito, Rafał Jakieła, Maciej Sawicki, Jacek A. Majewski, Tomasz Dietl, and Alberta Bonanni, *Manipulating Mn²⁺ complex cation complexes to control the charge- and spin-state of Mn in GaN*, [Scientific Reports 2, 722 \(2012\)](#).
+ Patent (A50247/2012) – Semiconductor laser (GaN z Mn⁵⁺ jako materiał aktywny w laserze IR)
- Piotr Wojnar, Elżbieta Janik, Lech T. Baczewski, Sławomir Kret, Elżbieta Dynowska, Tomasz Wojciechowski, Jan Suffczyński, Joanna Papierska, Piotr Kossacki, Grzegorz Karczewski, Jacek Kossut, and Tomasz Wojtowicz, *Giant Spin Splitting in Optically Active ZnMnTe/ZnMgTe Core/Shell Nanowires*, [Nano Letters 12, 3404 \(2012\)](#).

Publikacje

Bliski horyzont:

M. Koba, J. Suffczyński, *Magneto-Optical Effects Enhancement in DMS Layers Utilizing 1-D Photonic Crystal*,

wysłane do ***Progress in Electromagnetic Research***

J. Papierska et al., *Modification of emission properties of ZnO layers due to plasmonic near-field coupling to self-organized Ag nanoislands*,

napisane i zredagowane, trwa doróbka przed wysłaniem

J.G. Rousset et al., *Magnetic circular dichroism in wurtzite structure DMS: (Ga,Fe)N*,

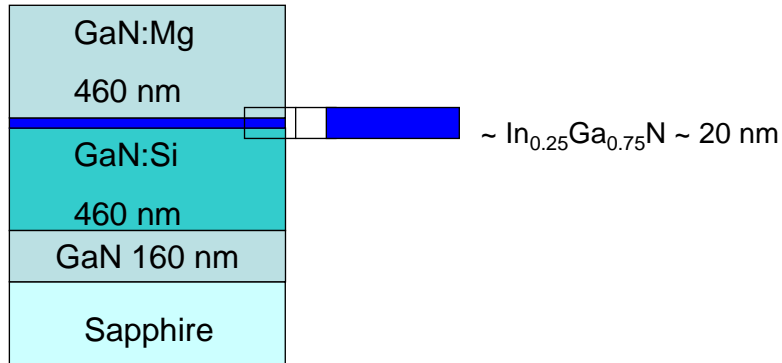
napisane, trwa redagowanie

K. Gałkowski et al., *Properties of emission from ZnMnTe/ZnMgTe core/shell nanowires*,

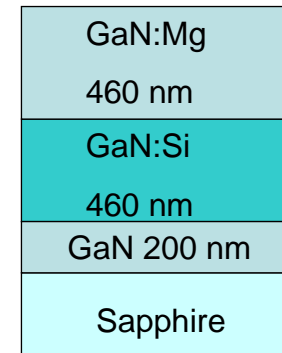
napisane, czeka na redakcję

p-n junctions with (Ga,Fe)N

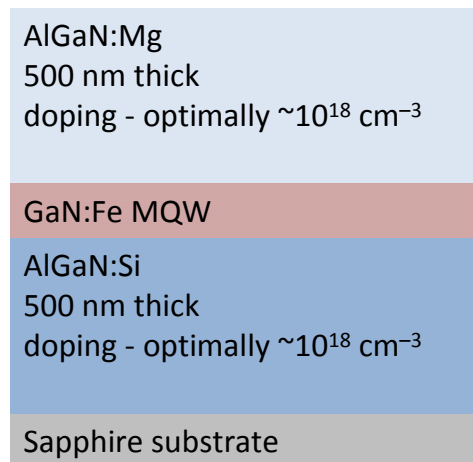
p-n 1624



p-n 1693



Sample 1714: AlGaN p-n junction

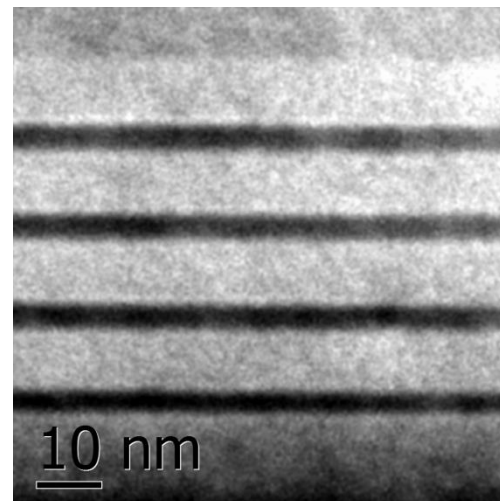
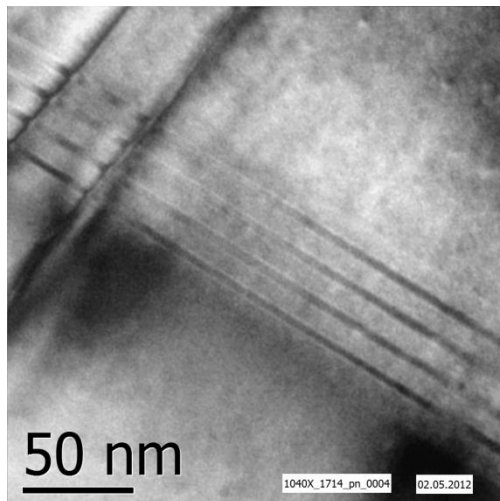
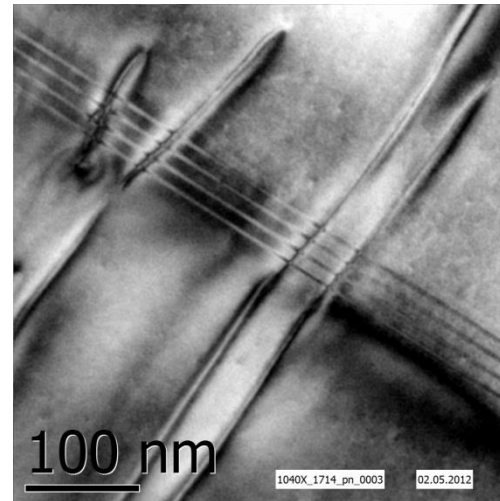
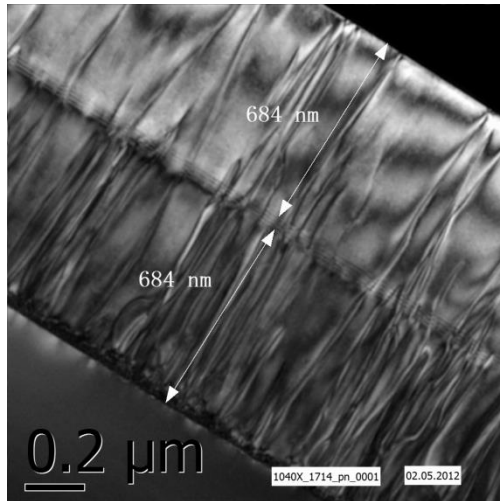


Close up of the active layer



Wzrost próbek
A. Navarro-Quezada,
A. Boanni

TEM characterization

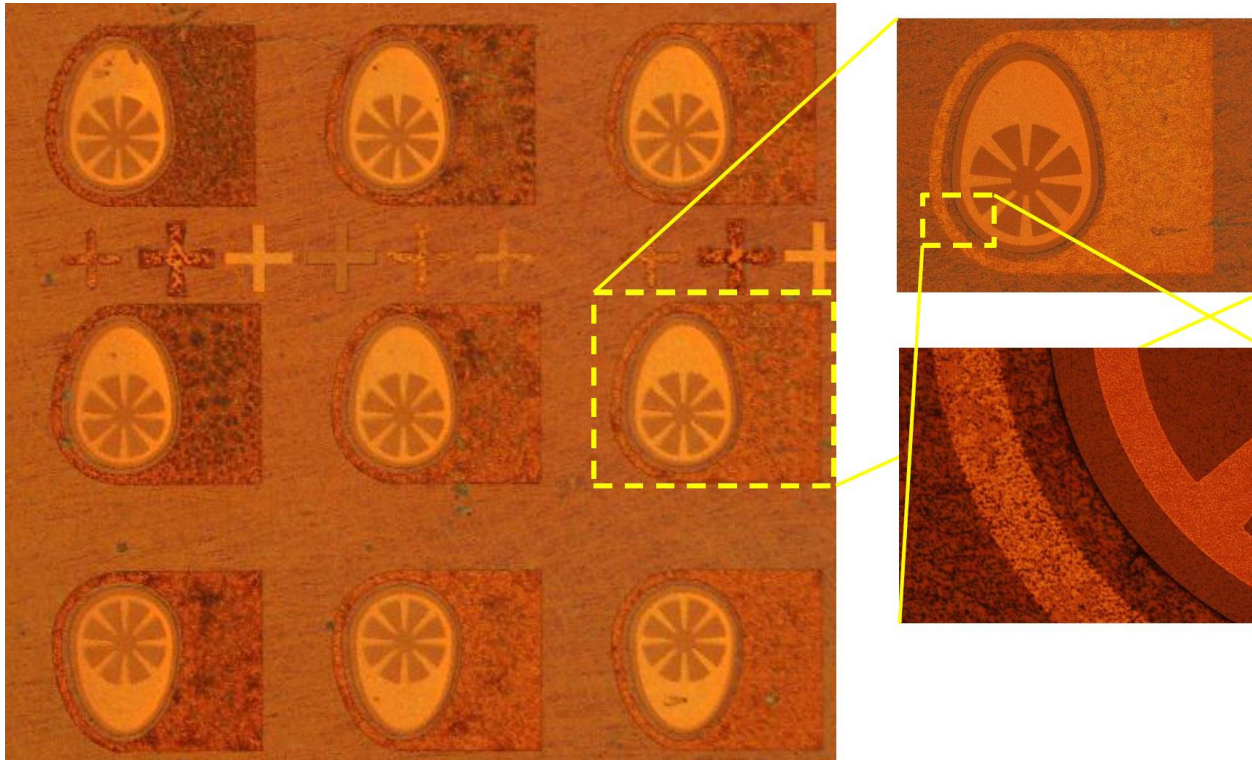


AlGaIn:Mg

$\text{Al}_{0.1}\text{Ga}_{0.9}\text{N}$
GaFeN

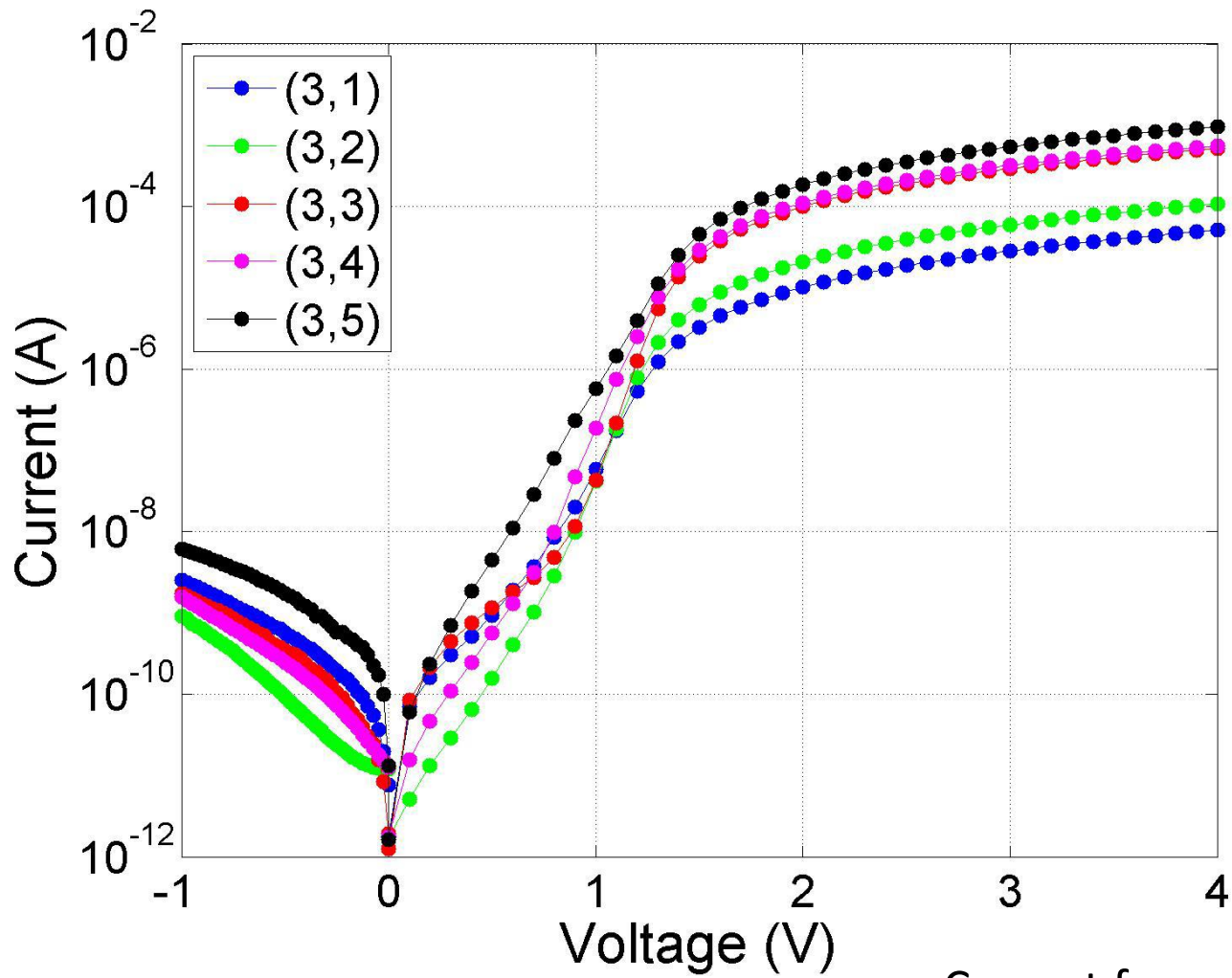
JKU, Linz
Tian Li

Sample preparation



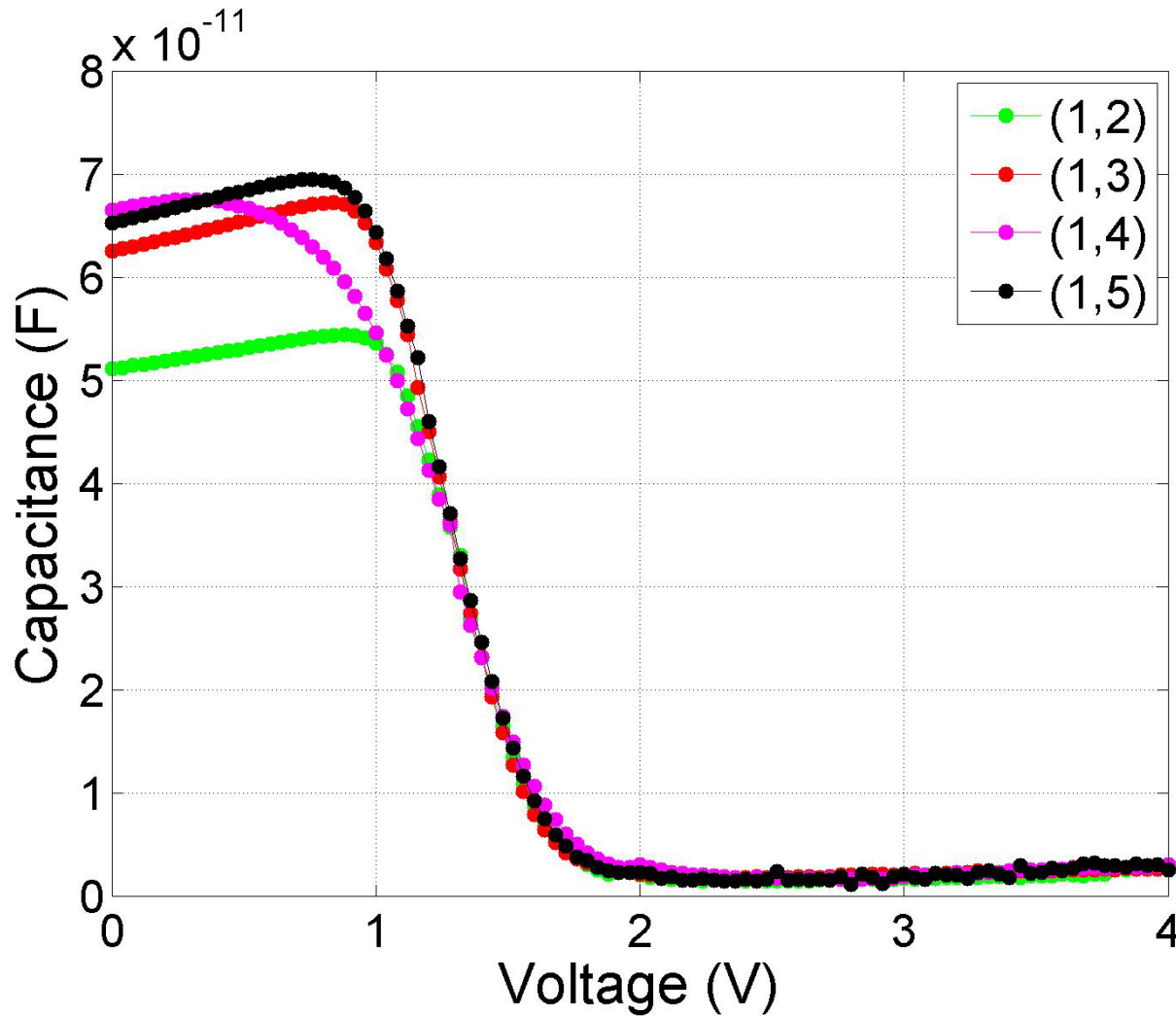
Mesas etched in ITE (M. Ekielski, K. Gołaszewska, E. Kaminska)

I-V characteristics



Current for:
forward voltage 10^{-3} A at 4V;
reverse voltage 10^{-8} A at -1V.

C-V characteristics



Information on depletion layer widths and carrier concentration?

Summary: p-n junctions

- I-V dependence as in the case of standard p-n junction
- Most of the mesas exhibit similar quantitative and qualitative dependences → homogeneity of the sample and good quality of deposited contacts

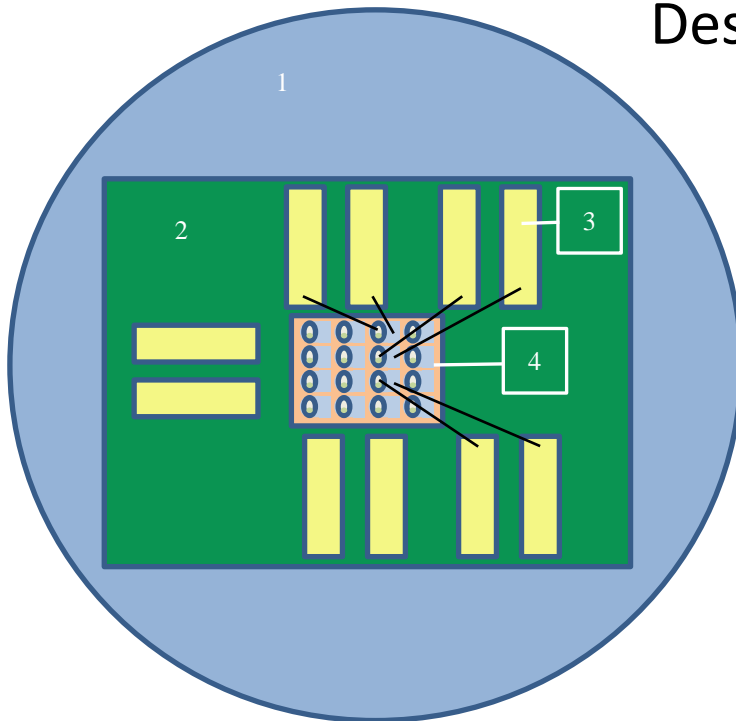
In progress:

- I-V and C-V characteristics modeling and analysis
- Bonding wires to selected, best contact pads

To do:

- Photo- and electroluminescence measurements in low temperature
- Verification of possible e-m radiation detection capabilities of the junction

Designed contact pad

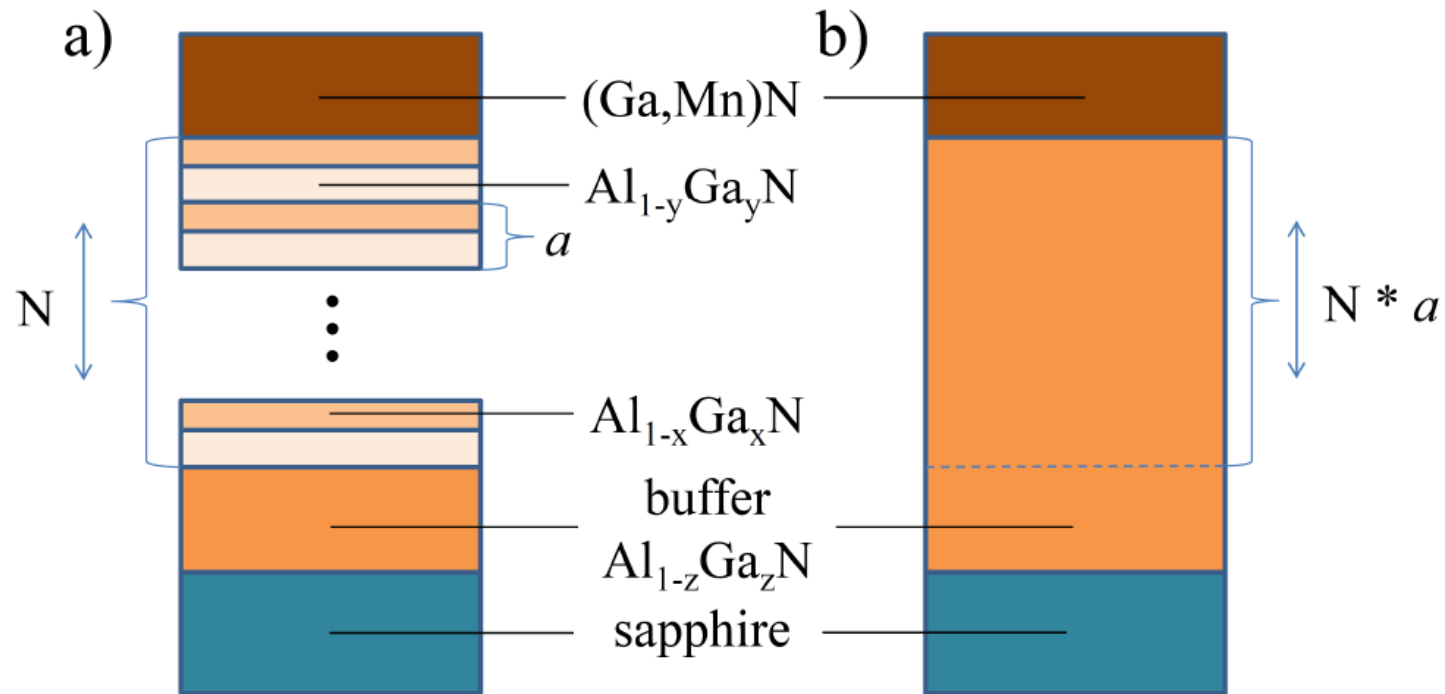


Perspective

- Spin-LED
- High carrier density in GaFeN QWs...

Photonic enhancement of Magneto-optical Kerr effect (MOKE) in $(\text{Ga,Mn})\text{N}$ / $(\text{Cd,Mn})\text{Te}$

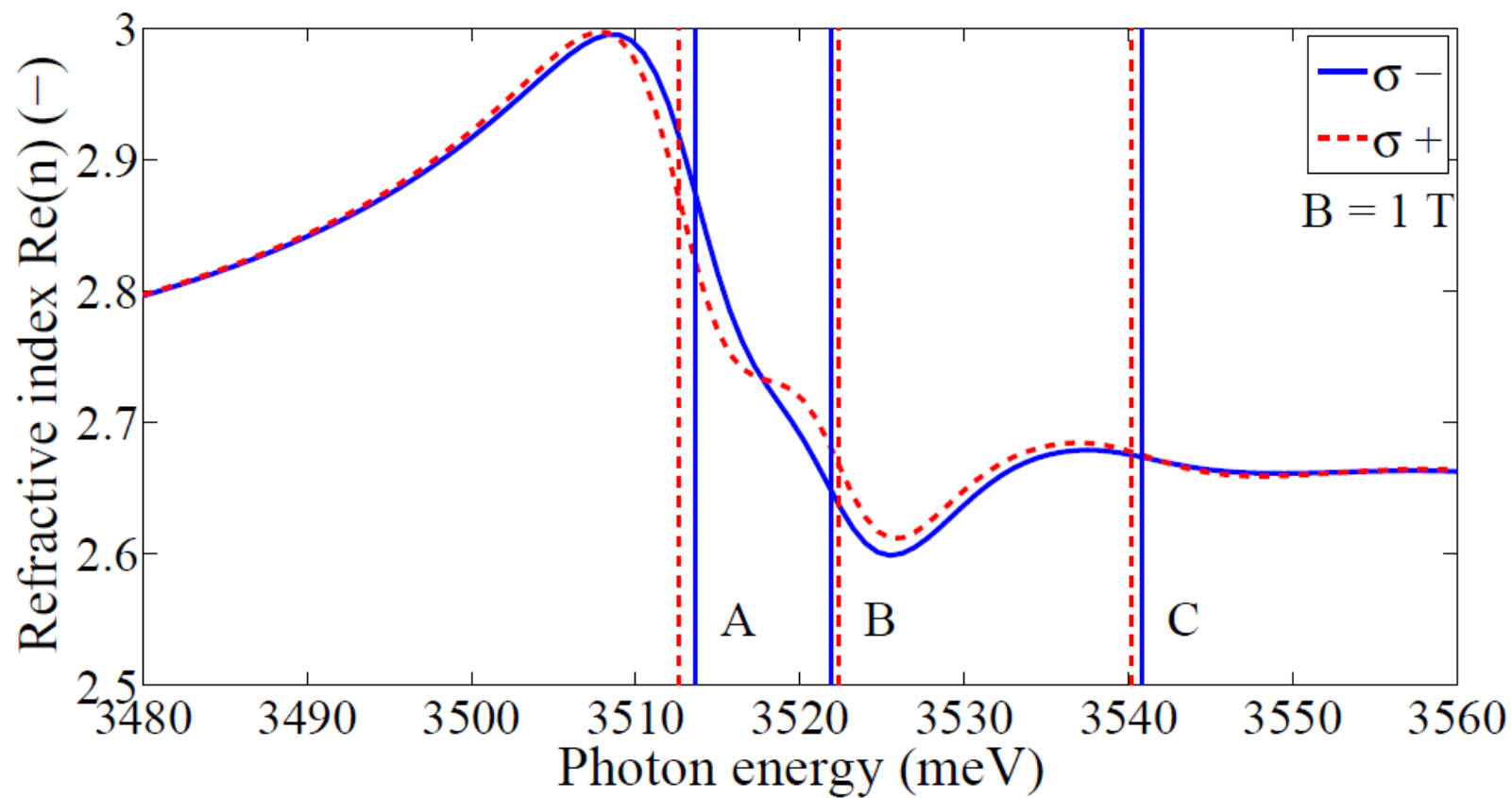
Sample design



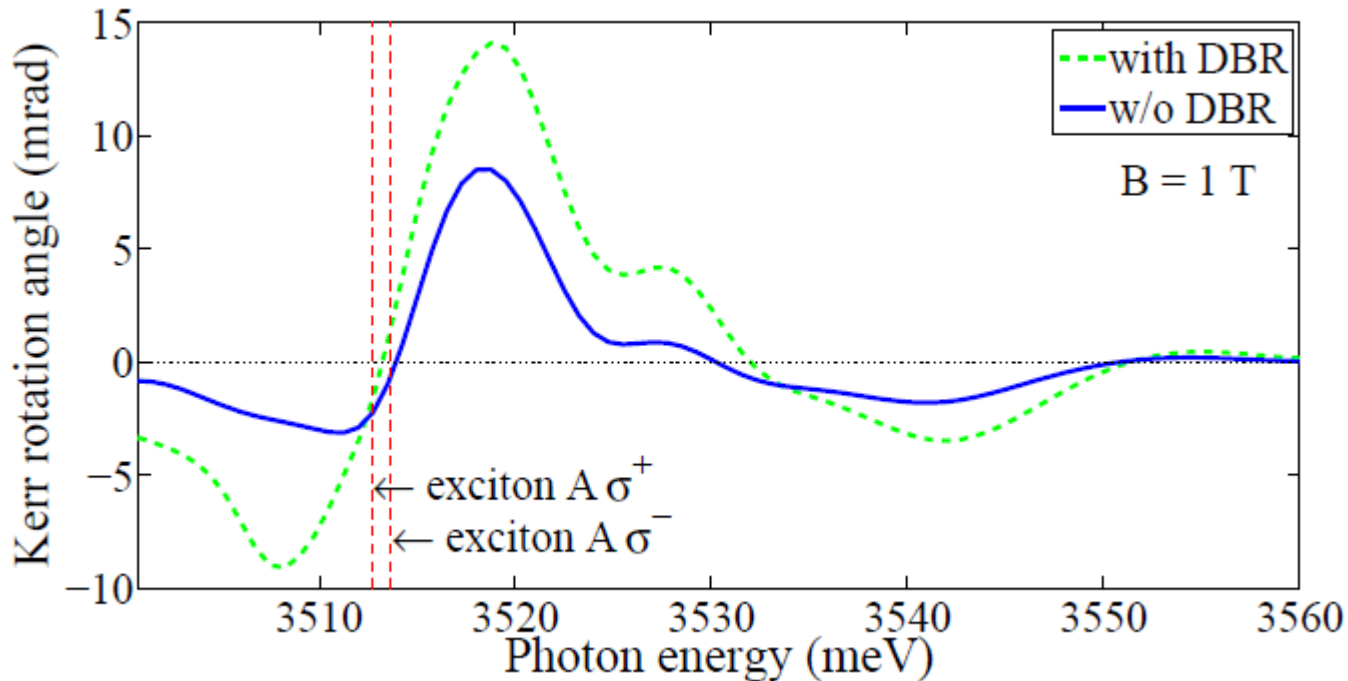
Realistic parameters assumed. E.g.:

- small contrast of refractive indices of layers constituting the DBR
- AlGaN buffer on Sapphire

Calculated GaMnN dielectric function



Calculated Kerr rotation angle GaMnN

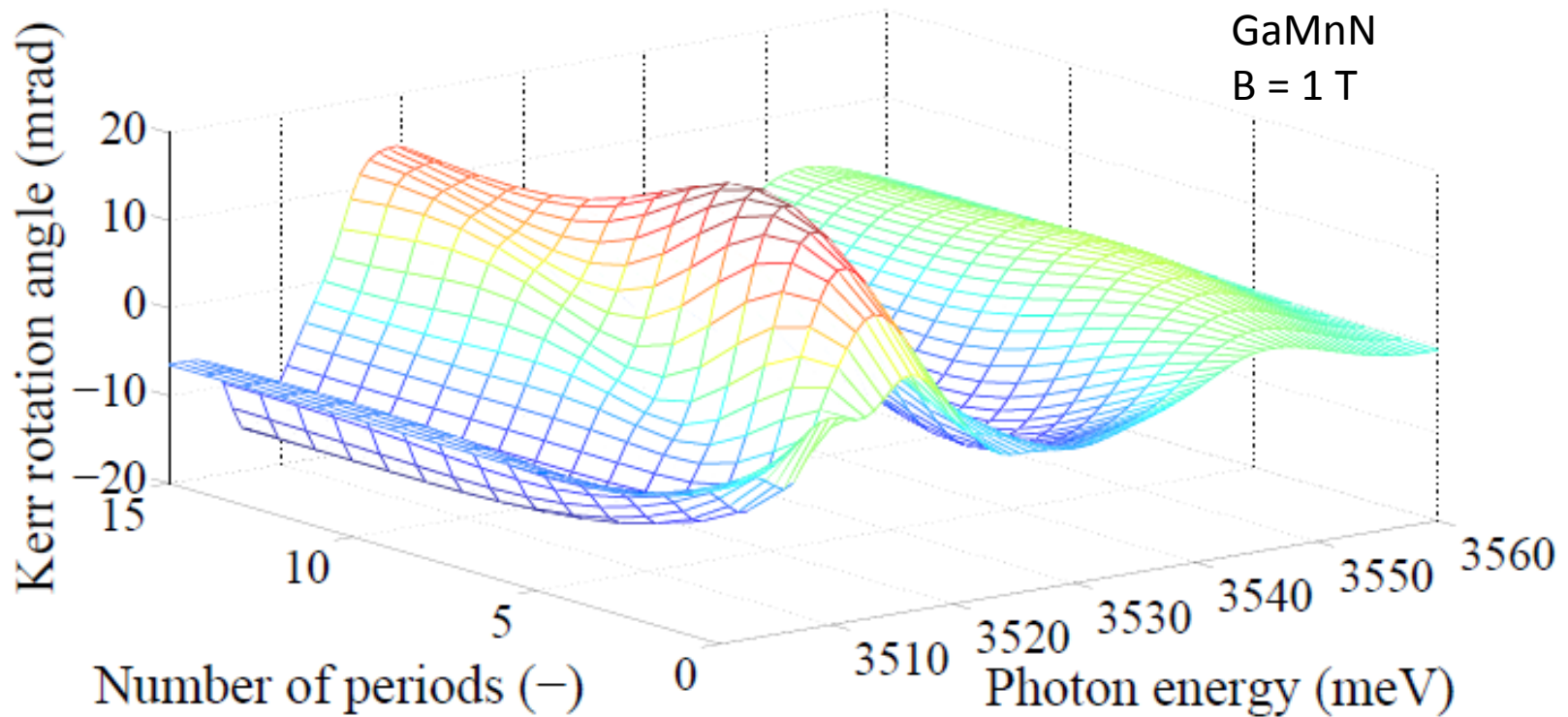


$$\Theta_K = \frac{1}{2} \arg \frac{r^-}{r^+}$$

r- and r+ : complex amplitudes of reflectivity coefficients for sigma - and sigma + circular polarizations

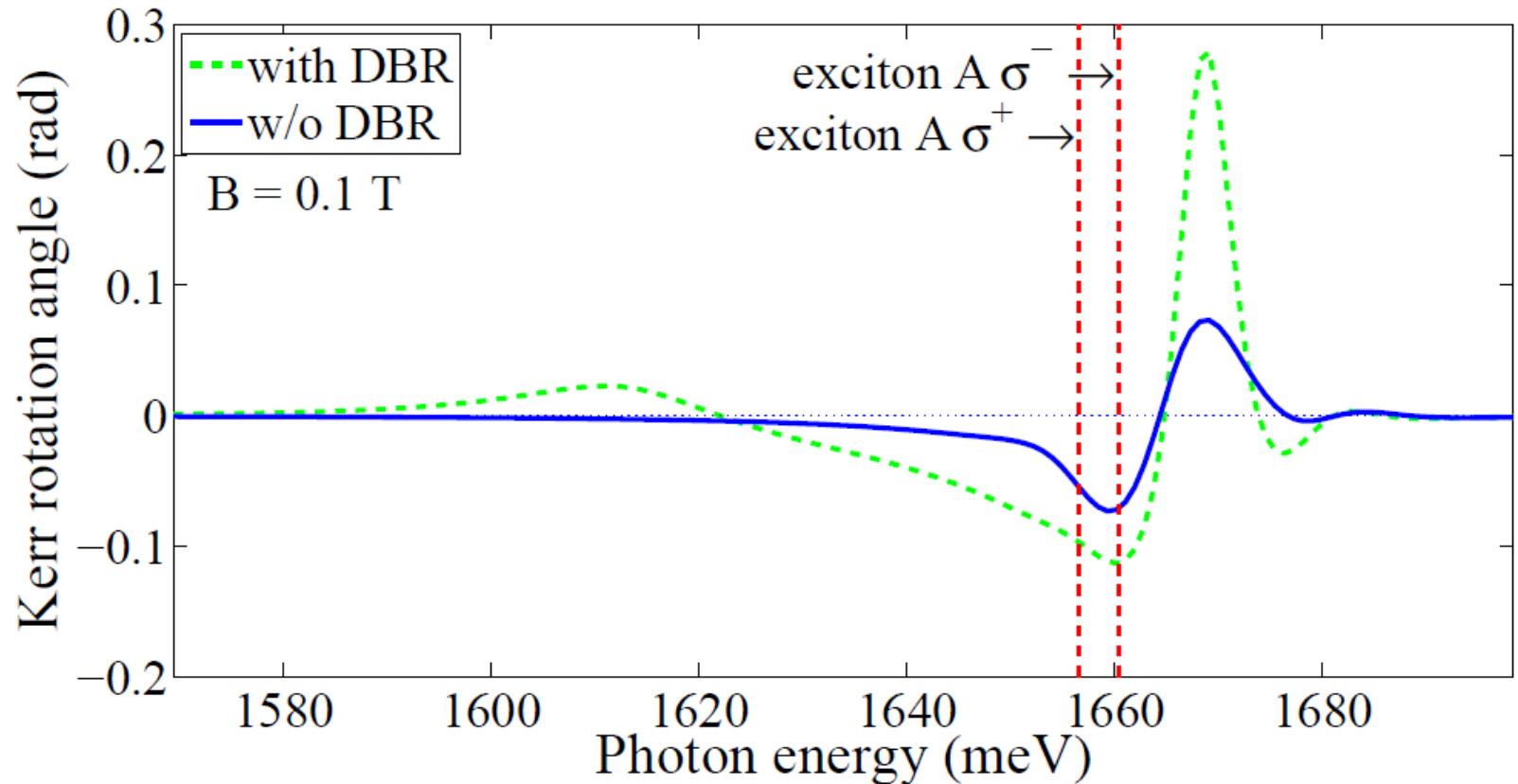
MOKE amplitude enhanced

Calculated Kerr rotation angle vs number of periods in Bragg mirror



Saturation at ~ 4 periods

Calculated Kerr rotation angle CdMnTe



MOKE amplitude enhanced

Summary – MOKE + DBR

- a significant amplification of the magneto-optical effects even for small number of periods and low contrast of refractive indices of layers within the DBR
- broadening of the range of magnetic ion concentrations within the DMS for which MOKE could be observed
- proposed design is valid for the case of both, wurtzite III-V and zinc-blende II-VI DMS.