

物理工学談話会 11月9日(金) 午後14:40~

会場: 総合研究棟W701 世話人: レービガー ハンネス

何方でも気楽にご参加ください

(Ga,Mn)N希薄磁性半導: 結晶成長、磁気物性、ピエゾ磁性

Effects of Substrate Temperature on Magnetic Properties of
(Ga,Mn)N grown by Molecular Beam Epitaxy

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The results of studies quantifying the impact of the growth temperature T_g on the structural and magnetic properties of (Ga,Mn)N will be presented [1]. Our $\text{Ga}_{1-x}\text{Mn}_x\text{N}$ layers have been grown by plasma assisted molecular beam epitaxy having the x value tuned from 0.2 to 10% solely by changing T_g between 700 and 590°C, respectively. Wide-ranged structural characterization by AFM, SIMS, TEM, and XRD do not reveal any crystallographic phase separation or precipitations. XANES spectroscopy supported by DFT modelling and SQUID magnetometry points to the predominantly Mn^{3+} configuration for which the ferromagnetic phase due to superexchange spin-spin coupling is observed in layers with $x > 5\%$ at $3 < T < 10$ K. Fine substrates' surface temperature mapping shows that the magnitudes of both x and Curie temperature T_C correlate with local T_g . The observed 10°C variation of T_g across 1" substrate leads to 40% dispersion of T_C . It will be shown that two different methods of T_C determination allow for quantification of Mn ions distribution within the material.

[1] K. Gas *et al.*, *Impact of substrate temperature on magnetic properties of plasma-assisted molecular beam epitaxy grown (Ga,Mn)N*, *J. Alloys Compd.* **747**, 946 (2018).

Piezoelectromagnetic effects in ferromagnetic (Ga,Mn)N layers

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Switching of magnetization direction between two stable states separated by an energy barrier is one of the most important processes for magnetic recording and information storage. This energetically costly scheme is conventionally done by applying an external magnetic field or spin polarized currents. An electric-field-control of magnetic anisotropy is a promising candidate to overcome the large energy budget of the conventional methods. We anticipate that this can be accomplished in (Ga,Mn)N, where owing to the inverse piezoelectric effect it is possible to manipulate the single ion magnetic anisotropy of the individual Mn species by electric field [1]. During the talk, direct magnetic observation of a strong reduction of the width of the hysteresis curve and a non-reversible magnetization switching for magnetic fields close to the coercive field for the ferromagnetic (Ga,Mn)N layers under the influence of external electric field will be presented.

[1] D. Sztenkiel, M. Foltyn, G.P. Mazur, R. Adhikari, K. Kosiel, K. Gas, M. Zgirski, R. Kruszka, R. Jakiela, Tian Li, A. Piotrowska, A. Bonanni, M. Sawicki, and T. Dietl, *Stretching magnetism with an electric field in a nitride semiconductor*, *Nature Commun.* **7**, 13232 (2016).