Spin-polarization of excitons in GaN

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Exciton spin relaxation in bulk GaN was directly observed with sufficient time resolution for the first time, to our knowledge. The obtained spin relaxation times are 0.69 ps - 0.27 ps at 150 K - 200 K. These are at least one order of magnitude shorter than those of the other III-V compound semiconductors. The spin relaxation time, τ_s, is found to be proportional to $T^{-3.2}$, where T is the temperature.

The spin relaxation in semiconductors is of interest from the viewpoints of fundamental physics as well as the possible applications of spin-dependent optical nonlinearity such as all optical ultrafast switching, vertical cavity surface emitting laser diode and quantum computing. However, the spin relaxation time in GaN has not yet been measured. The spin-dependent pump and probe reflection measurement enables us to observe the spin relaxation process with an extremely high time resolution of 0.18 ps [1]. The sample is 2.2 μm thick GaN grown on a sapphire substrate following a 40-nm-thick GaN buffer layer by metal-organic chemical vapor deposition. Frequency-doubled femtosecond optical pulses generated from a Ti:sapphire laser are used as the pump and probe pulses. The circularly polarized pump pulse initially excites spin-aligned carriers, and then the circularly polarized time-delayed probe pulse detects the population change of the spin polarized carriers.

Figure 1 shows the measured time evolution of the spin dependent intensity of reflection at 150 K. To excite the A-free excitons (FEA) resonantly, the energy of the excitation laser pulses was matched to the FEA PL peak (3.47 eV at 150 K). I_+ (I_-) indicates a right circularly polarized excitation and a right (left) circularly polarized probe. Note that the spin polarization $(I_+ - I_-)/(I_+ + I_-)$ is clearly observed. The single exponential fitting gives the spin relaxation time of 0.69 ps. This relaxation time is at least one order of magnitude shorter than 5.2 ps in InGaAs/InP multiple quantum wells (MQWs) and 32 ps in GaAs/AlGaAs MQWs [2]. The observed sub-picoseocnd spin relaxation shows the high potential of GaN as a promising material for the ultrafast optical devices.

The spin relaxation mechanism is known to be greatly affected by the band structure. The candidates of the spin relaxation mechanism revealing the strong temperature dependence are D'ya konov-Perel process which is induced by spin orbit-splitting and Elliot-Yafet (EY) process which is caused by carrier scattering. The fact that the spin relaxation time in GaN is shorter than that in GaAs, in spite of the small spin-orbit splitting, suggests that the spin relaxation is dominated by the EY process, which is considered to be strongly enhanced by the defects.

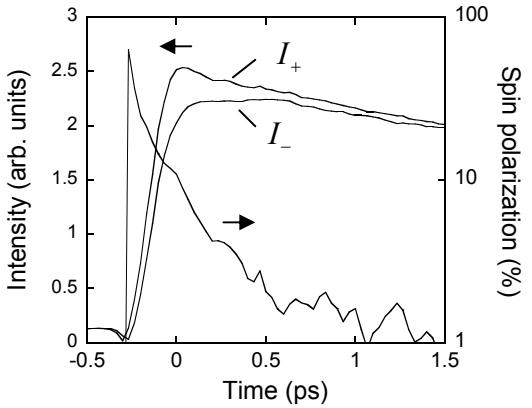

Fig.1 Observed time evolution of intensity of reflection and spin polarization at 150K.

[1] A.Tackeuchi, S. Muto, T. Inata and T. Fujii,, Appl. Phys. Lett. **56**, 2213 (1990).
[2] A. Tackeuchi, T. Kuroda, S. Muto, Y. Nishikawa and O. Wada, Jpn. J. Appl. Phys. **38** (1999) 4680.

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