フォトニックバンドギャップ効果による単一 InAs/ GaAs 量子ドット内動的核スピン偏極の制御

Modulation of Dynamic Nuclear Spin Polarization in Single InAs/GaAs Quantum Dots by Photonic Bandgap Effect

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Self-assembled quantum dot (QD) is a promising candidate for spin-based quantum information application. However, in III-V semiconductors, the fluctuating nuclear spin environment has been a source of spin decoherence[1]. Dynamic nuclear spin polarization (DNP) which involves the transfer of electron spin to the nuclei has been proposed as a method to eliminate or reduce the nuclear spin fluctuation.[1] One of the main obstacles in achieving high nuclear spin polarization degrees is the requirement for fast injection and removal of spin polarized electrons from the QD which would be ultimately limited by the radiative lifetime of the confined carriers in a QD[2]. Here, we report the modification of DNP in single InAs/GaAs QDs embedded in 2D photonic crystals (PhC), in which photonic bandgap effect modifies QD's radiative process. We observed that the modified radiative lifetime significantly alters the DNP physics in QDs. This result will open the way for controlling DNP by photonic nanostructures.

Measurements were performed on a number of QDs within and without PhC under non-resonant excitation. It was observed that the Overhauser Shift (OS) and the degree of circular polarization of emission (DOP) of suitable QD emission - both measures of the degree of DNP - show clear decrease in magnitude with increasing radiative lifetime (Fig 1(a, b)). Longer radiative lifetime could result in less number of cycles of excitation and removal of electron spin per unit time, meaning lower rate of spin transfer from electron to nuclei and thus giving less nuclear spin polarization. The behaviour of the OS with radiative lifetime is simulated showing consistent behaviour with experimental results.

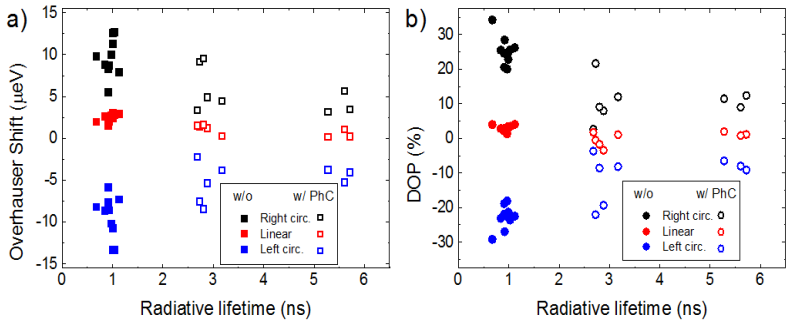

Fig. 1 Decrease of magnitude (a) OS and (b) DOP of QD emission with increasing radiative lifetime under right and left-circular polarization excitation. Linearly polarized excitation produces little nuclear spin polarization. All the measurements were performed at pump powers at which QD emission saturates.

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