アンドープ GaAs 量子井戸における光注入長寿命キャリアのスピン軌道相互作用

Spin-orbit interaction of photo-injected long-lived carriers in undoped GaAs quantum wells

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Preserving spin polarization in non-magnetic semiconductors is essential for future spin-based electronics. Spin-orbit interaction (SOI) plays key roles in the processes of spin randomization and spin precession in two-dimensional systems [1]. We have previously reported the unexpectedly long decay time (>10 ns) of a Kerr rotation (KR) signal in an undoped GaAs quantum well (QW) [2]. This decay time is possibly caused by spin-polarized dark excitons or localized electrons, but the origin has yet to be clarified in detail. Here, we carried out time and spatially resolved KR measurements to analyze the SOI of carriers relevant to the observed KR signal. The results revealed that the symmetry of the spin-orbit effective magnetic fields ($\mathbf{B}_{SOI}$) agrees with that of the Dresselhaus SOI of the conduction band electrons.

The samples we studied contained a single undoped 20-nm-thick GaAs/AlGaAs (001) QW. In an externally applied in-plane magnetic field ($\mathbf{B}_{ext}$), time-resolved KR probed at the center of the pump spot exhibits the spin precession with the frequency determined by $\mathbf{B}_{ext}$ and the g-factor. The probe position dependence of the precession frequency provides information about SOIs [3]. Since the spins probed at a position separate from the spin injection spot have experienced an additional average momentum, they should also have experienced an additional B_{SOI}. We applied $|\mathbf{B}_{ext}|$= 100 mT in several in-plane directions and scanned the probe positions in directions parallel and perpendicular to $\mathbf{B}_{ext}$. Half of the data in Fig. 1 show that the precession frequencies increase as we scan the probe position, whereas the remaining data show a constant precession frequency. We derived the $\mathbf{B}_{SOI}$ directions with respect to the different momentum vectors. The symmetry of $\mathbf{B}_{SOI}$ completely agrees with that of the Dresselhaus SOI of conduction band electrons, indicating the only electrons contribute to the spin diffusion signal. The result implies that the photo-excited electron-hole pairs are separated by unintentional potential modulations, and the spin-polarized electrons are stored for a long time. The ability to access such locally-stored and long-lived spins allows us sufficient time to analyze and manipulate the spin dynamics before the spin coherence vanishes.

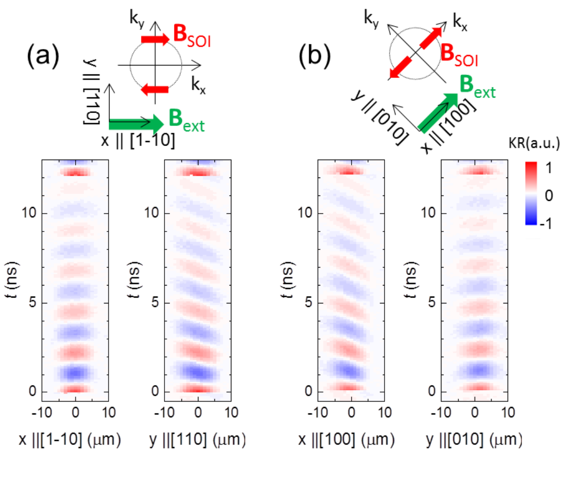

Fig. 1 KR signals plotted as a function of the delay time and probe position. $\mathbf{B}_{ext}$ was applied in the [1-10] (a) and [100] (b) directions.

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[1] See for example, Y. Kunihashi *et al*. Nat. Commun. **7**, 10722 (2016).

[2] H. Sanada *et al.*, JSPS spring meeting (2017).

[3] M. Kohda *et al.*, Appl. Phys. Lett. **107**, 172402 (2015).