# Spectral Dependence and Current-Induced Spin Polarization in a Rashba system

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*The converse effects of spin photocurrent and current induced spin polarization are experimentally demonstrated in a two-dimensional electron gas (2DEG) system with Rashba spin splitting. Structural Inversion Asymmetry (SIA), which induces the Rashba interaction, was achieved in two samples (named D and E) by δ doping of only one side of the confining barrier layer of InGaAs-based quantum wells. Enhanced SIA in one sample (E) was obtained by a graded In composition instead of the usual uniform composition. Beating of the Shubnikov-de Haas (SdH) oscillations reveals a unified picture for the spin photocurrent, current-induced spin-polarization, and spin-orbit coupling.*

SdH oscillations and their pronounced beating patterns at low magnetic field are revealed in Figs. 1(a) and 1(b) by the first derivative of the magneto-resistance, $R_{xx}$. The fast fourier transform (FFT) spectra give the density of the two kinds of carriers as shown in Figs. 1(c) and 1(d). The distinct beating pattern in the SdH oscillations are believed to arise due to spin splitting in the 2DEGs. The Rashba coefficients of samples D and E are $3.0 \times 10^{-12}$ eV m and $6.3 \times 10^{-12}$ eV m, respectively, indicating that the spin orbit interaction is larger when the inversion asymmetry is larger.

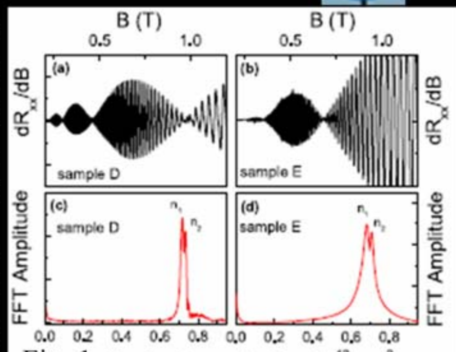


Fig. 1

Figs. 2(a) and 2(b) show the helicity dependence (represented by angle $\phi$ with $\phi = \pm 45°$ indicating left- or right-hand circular polarized light) of the spin photocurrent, with oblique incidence angle of 30° and laser power of 100 mW (λ=880 nm) at 10 K. The laser wavelength is in the range for interband excitations. The solid lines are fits of $\sin 2\phi$. Fig. 2(c) depicts the microscopic origin of the circular photogalvanic effect (CPGE) induced photocurrent. The vertical arrow shows the permitted transitions with $\sigma^-$ excitation and the horizontal arrow indicates the final direction of the induced photocurrent. Fig. 2(d) is the incidence angle Θ dependence of the photocurrent. The efficiency is two orders higher than that using intraband excitation and the ratio is a bit less than 3 between these two samples. The spectral dependence of the spin photocurrent (not shown here) shows that the excitation from heavy and light holes will result in reversed current.

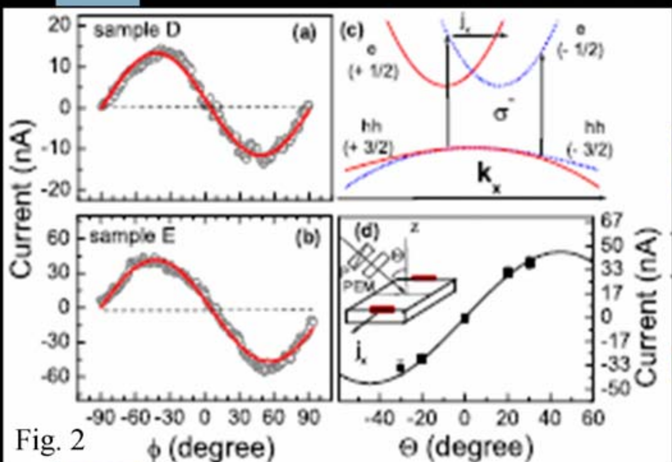


Fig. 2

Fig. 3 shows the electric field ($E_x$) dependence of the Kerr rotation of sample D (a) and E (b) at 10 K, indicating current induced spin polarization. The temperature dependence of the Kerr rotation of sample D ($E_x$ = 50 V/cm) is shown in the inset of Fig. 3(a). The experimental setup is schematically shown in the inset of Fig. 3(b), in which *P*1 and *P*2 represent the polarizer and analyzer, respectively. The relative efficiency ratio for the two samples is again about 3 to 4.

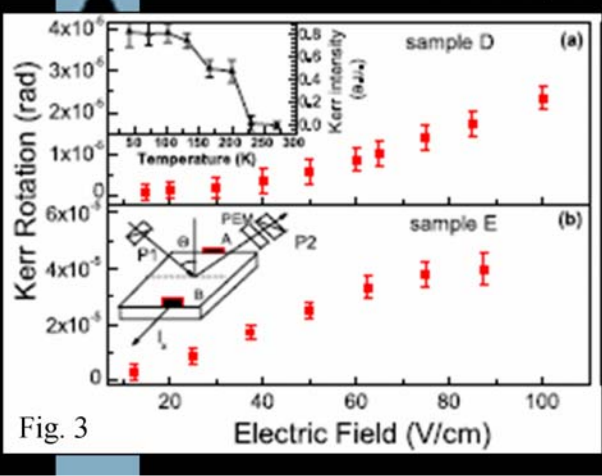


Fig. 3