Valley control in Si 2D electrons and its effect on 2D physics
Si 二次元電子系の谷制御と二次元物性への影響

In 2006, we found the giant valley splitting of Si two-dimensional (2D) electron system when electrons are pushed to an interface of a buried oxide (BOX) formed by oxygen implantation and high-temperature annealing (Takashina *et al.*, PRL2006). One can control the valley splitting by an induced electric field in this system. We checked mobility of the carriers to understand the mechanism behind the giant valley splitting. In contrast to the electron mobility, which is strongly suppressed at the Si/BOX interface with giant valley splitting, the hole mobility shows higher values compared to the standard Si/Thermal-oxide interface. This strongly suggests that the suppression of the electron mobility at the Si/BOX interface is not due to a particularly adverse magnitude of the surface roughness but dominated by the physics of valley polarization.
A combination of this gate-control valley-splitting and parallel-field spin-splitting provides us controlled study of spin and valley freedoms. Figure 1 summarizes a coarse but global phenomenology of how the resistivity depends on its key parameters: spin and valley polarization, density, and disorder. Although disorder induced insulating behavior appears in (a), the metallic characteristics are strong in spin and valley degeneracy systems ((b) & (c)). The spin polarization and valley polarization have quantitatively similar effects on the resistivity as shown in (d)-(h). The insulating behavior becomes prominent in spin and valley split systems ((i) and (j)). These results provide important information for a study of the metal-insulator transition in a 2D system.
On the other hand, we experimentally show that less magnetic field can be required to fully spin polarize a valley-polarized system than a valley-degenerate one in contrast to expectations from a non-interacting model. The obtained results can be understood as a manifestation of the greater stability of the spin-and valley-degenerate system against ferromagnetic instability.

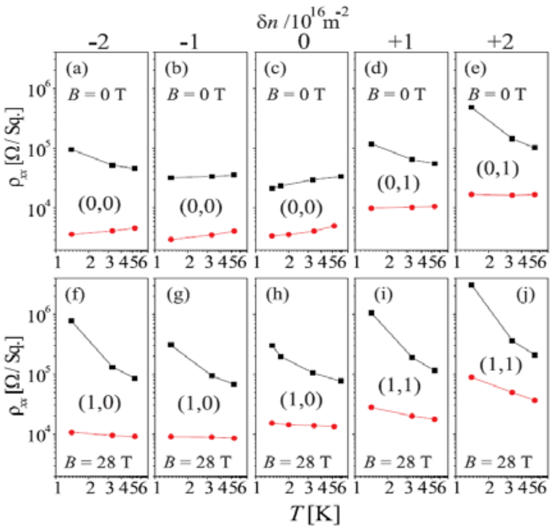

Fig. 1 Temperature dependence of resistivity (squares: n=2.5×10^{15}m^{-2}, circles: n=4.5×10^{15} m^{-2}). Data at *B* = 0 T are shown in the top rows [(a)-(e)] while the lower rows [(f)-(j)] show data at *B* = 28 T. Each column corresponds to a value of δn. Polarization (P_S,P_V) for n=2.5×10^{15}m^{-2} is indicated in parentheses for each graph. Polarization at n=4.5×10^{15}m^{-2} is the same except in (d) where P_V=0.87 and (i) and (j) where the degree of spin-valley polarization is substantial but not full.

Representative publication:
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