Vertical electric filed-tunable effective g*-factor of holes in a compressively strained germanium quantum well grown on silicon

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For development of large-scale quantum computers based on spin qubits and for other spin-based devices, a continues search and development of advanced material systems with predictable and controllable g-factors is highly desirable. As a future long-term goal for a practical quantum computer, for in order to design and calibrate each qubit of a one million qubit circuit, it is very much preferable that the effective g-factor would entirely depend on the material stack and can be controlled by the perpendicular electric filed produced by the surface gates. Exactly this situation has been recently achieved and will be presented in this talk.[1]

We experimentally study the electric-field tunability of effective g*-factor of holes in a large ($100 \times 400\,\mu m^2$) gated Hall bar device fabricated from a compressively strained germanium on a standard silicon wafer (cs-GoS). Thanks to a very high mobility of carriers [2] it became possible to developed a special semi-empirical approach based on the Arrhenius-plot analysis to gain reliable information about the material's g*-factor and its tunability. The extracted effective hole g*-factor as a function of the accumulation gate voltage is shown in Figure 1. It is evident that as a result of the material stack engineering, the effective g*-factor can be tuned in a large range from 13 to 24 that corresponds to the tuneable Zeeman spin splitting of heavy holes in the large range from smaller to equal, and to larger than the orbital Landau level quantization gap.[1]

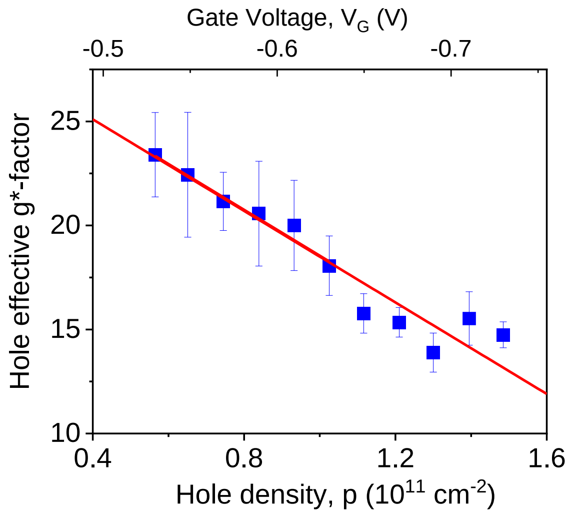

Fig. 1. Hole effective g*-factor as a function of the 2DHG areal density (bottom axis) or the gate voltage

Note, that g*-factor in the reported cs-GoS material system is over 10 times larger than that of other materials, including group-IV and III-V semiconductors (g*(GaAs)≈0.44) and Si (g*(Si)≈2). The obtained results are very appealing to both for studies of fundamental physics, e.g. the ferromagnetic phase transitions and the fractional quantum Hall effect involving spin states, and also opens new opportunities for developments of spin-based devices such as qubits, spin field-effect and spin-orbit transistors operating at elevated temperatures

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References

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