

High-field galvanomagnetic response of graphene and InSb-based hallotrons

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Emerging technologies such as fusion energy systems and space applications increasingly demand electronic components capable of stable and predictable operation in multi-tesla magnetic fields over wide temperature ranges. Semiconductor Hall devices, particularly those based on InSb, are widely used in demanding conditions due to their high carrier mobility and sensitivity [1]. Controlled donor doping enables stabilization of electrical properties over broad temperatures. However, it simultaneously alters intrinsic transport properties and introduces trade-offs between sensitivity, thermal stability, and reproducibility. As a result, device performance may deviate from ideal behavior in strong magnetic fields. These limitations motivate the exploration of alternative materials for robust magnetic-field sensing, with graphene emerging as a promising candidate.

In this work, we present a comparative study of galvanomagnetic properties of two types of device-ready Hall sensor platforms: (i) p-type hydrogen-intercalated quasi-free-standing epitaxial graphene grown on 4H-SiC(0001) passivated with an Al₂O₃ [2], and (ii) heavily donor-doped InSb thin film deposited on semi-insulating GaAs substrate and protected with dielectric layer [3]. Both device types were integrated into CERDIP8 ceramic housing, ensuring suitability for operation in harsh environments. InSb structures with different doping levels were analysed to show the impact of transport properties on electrical response in strong magnetic field.

The galvanomagnetic response was investigated in magnetic fields up to 11 T at room temperature and under liquid-helium conditions. The graphene-based devices exhibit a monotonic and nearly linear Hall response across the full magnetic-field range, indicating weak magnetoresistive effects. In contrast, InSb-based sensors, due to intense doping, display significant nonlinearity and distortion in the transverse voltage at high magnetic fields. This effect originates from strong magnetoresistance, where the rapid increase of longitudinal resistance leads to mixing between longitudinal and transverse voltage components, distorting the Hall signal [4]. As a result, the usable magnetic-field range of semiconductor Hall devices becomes limited in the multi-tesla regime.

The results demonstrate that graphene Hall devices maintain superior stability of response under high magnetic field and cryogenic conditions. These findings highlight graphene as a promising material platform for reliable magnetic-field sensing in extreme environments where conventional semiconductor-based Hall sensors, such as InSb, may face intrinsic limitations.

References

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