Graphene Hall sensors developed for use at cryogenic temperatures and ultra-high magnetic fields

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It has been speculated that the excellent mechanical and electrical properties of graphene make it highly suitable for use in Hall sensors. [1] Paragraf's proprietary and commercially scalable graphene growth method [2] has allowed this to be realised, using high quality graphene grown directly on the device substrate to produce robust, highly sensitive Hall sensors specifically designed for cryogenic and high field applications.
Other high performance Hall sensors such as 2DEGs show significant non-linearities and voltage saturation at high fields, [3] therefore cannot be used over the full ultra-high field range. Effects such as charge freezing cause performance issues at cryogenic temperatures, making conventional sensors less suitable for use in areas such as superconductivity and quantum computing.
Accurate measurements in high magnetic fields and at cryogenic temperatures are possible with Paragraf's Hall sensor due to its high linearity, absence of planar hall effect and a temperature coefficient that is fractions of one percent, allowing simple, accurate calibration over a wide temperature range.
After 4 rounds of thermal cycling with a temperature range of 5 – 300 K, Paragraf's sensor showed a 0.1% change in device behaviour. This is minimal compared to the deviation expected from conventional sensors. The ultra-high magnetic field response at cryogenic temperatures was tested, with Paragraf's sensor giving a highly linear response in fields of up to 30 T at 1.5 K (**Figure 1**).
Due to their high sensitivities, Paragraf's Hall sensors outperform conventional sensors while requiring lower drive current and therefore producing less heat (of the order of pW).

References

[1] Song, G. et al. "Operation of graphene magnetic field sensors near the charge neutrality point." Communications Physics 2.1 (2019): 1-8.
[2] Thomas, S. "A method of producing a two-dimensional material", WO2017029470
[3] Popović, R. S. et al. "Nonlinearity in Hall devices and its compensation." Solid-state electronics 31.12 (1988): 1681-1688.

Figures

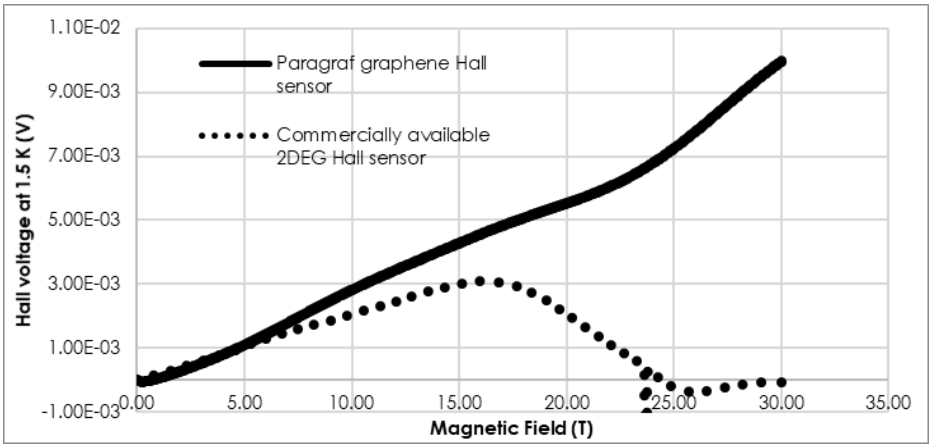

Figure 1: Hall voltage response at 1.5 K of Paragraf's graphene Hall sensor and a commercially available 2DEG sensor between 0 and 30 T. Paragraf's sensor shows a linear response over the full field range, whereas the 2DEG performance degrades significantly above 15 T. Data collection in collaboration with Uli Zeitler and Rubi Km at HFML, Radboud University, Nijmegan.