

Spin Transport in High Mobility Graphene Devices

P. J. Zomer, M. H. D. Guimarães, A. Veligura, T. Maassen, I. J. Vera-Marun, N. Tombros, and B. J. van Wees

Zernike Institute for Advanced Materials, Nijenborgh 4, Groningen, The Netherlands
p.j.zomer@rug.nl

Graphene is an excellent material for carrying spin information over long distances. At room temperature, a single layer graphene flake based on a SiO₂ substrate typically shows a spin relaxation time τ of ~ 150 ps and spin relaxation length λ of ~ 2 μm [1]. This clearly shows the potential that graphene possesses for spin transport. However, the measured spin relaxation time and length are still orders of magnitude smaller than what is theoretically predicted and the exact cause for this discrepancy remains unclear.

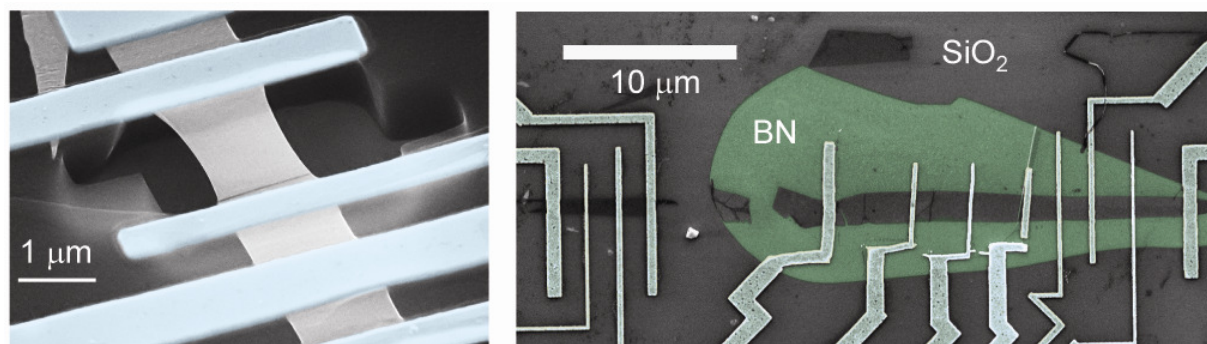
In order to pinpoint the limiting factors for graphene spin transport we follow two approaches to obtain superior quality devices as compared to the standard SiO₂ based samples. First, the graphene flakes are suspended, yielding charge carrier mobilities μ up to 3×10^5 cm²/(V s) [2]. Second, the SiO₂ is replaced by hexagonal boron nitride (BN), where μ reaches 4×10^4 cm²/(V s) [3]. Surprisingly, τ appears to remain unaffected, although for suspended graphene devices we find that the measured τ represents only a lower bound. For both cases we obtain a moderate increase in the maximum spin relaxation length $\lambda \geq 4.5$ μm , which is caused by an enhancement of charge carrier diffusion in the high mobility devices. For BN-based devices we could measure spin transport over record lengths up to 20 μm . From further analysis of our data, we find it best described by a combination of a D'Yakonov-Perel and Elliott-Yafet like spin relaxation mechanism.

Our measurements indicate that graphene roughness, charged impurities or surface phonons are not the dominant factor for spin relaxation in graphene. The improved device quality allows for spin transport over longer distances, but the experimental results can only give a lower bound for τ and λ . To shed more light on the matter, other aspects such as adsorbates on the graphene surface should be investigated.

References

- [1] N. Tombros, C. Jozsa, M. Popinciuc, H. T. Jonkman, and B. J. van Wees, *Nature* **448** (2007) 571.
- [2] M. H. D. Guimarães, A. Veligura, P. J. Zomer, T. Maassen, I. J. Vera-Marun, N. Tombros, and B. J. van Wees, *Nanoletters* **12** (2012) 3512.
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Figures



Scanning electron microscope images of a suspended (left) and a BN based spintronic graphene device (right) with cobalt electrodes. Part of the latter device is based on SiO₂ for comparison.