HYBRID GRAPHENE-GRAPHENE QUANTUM DOT PHOTOCONDUCTORS TO TEST FOR GAIN AND HIGH RESPONSIVITY

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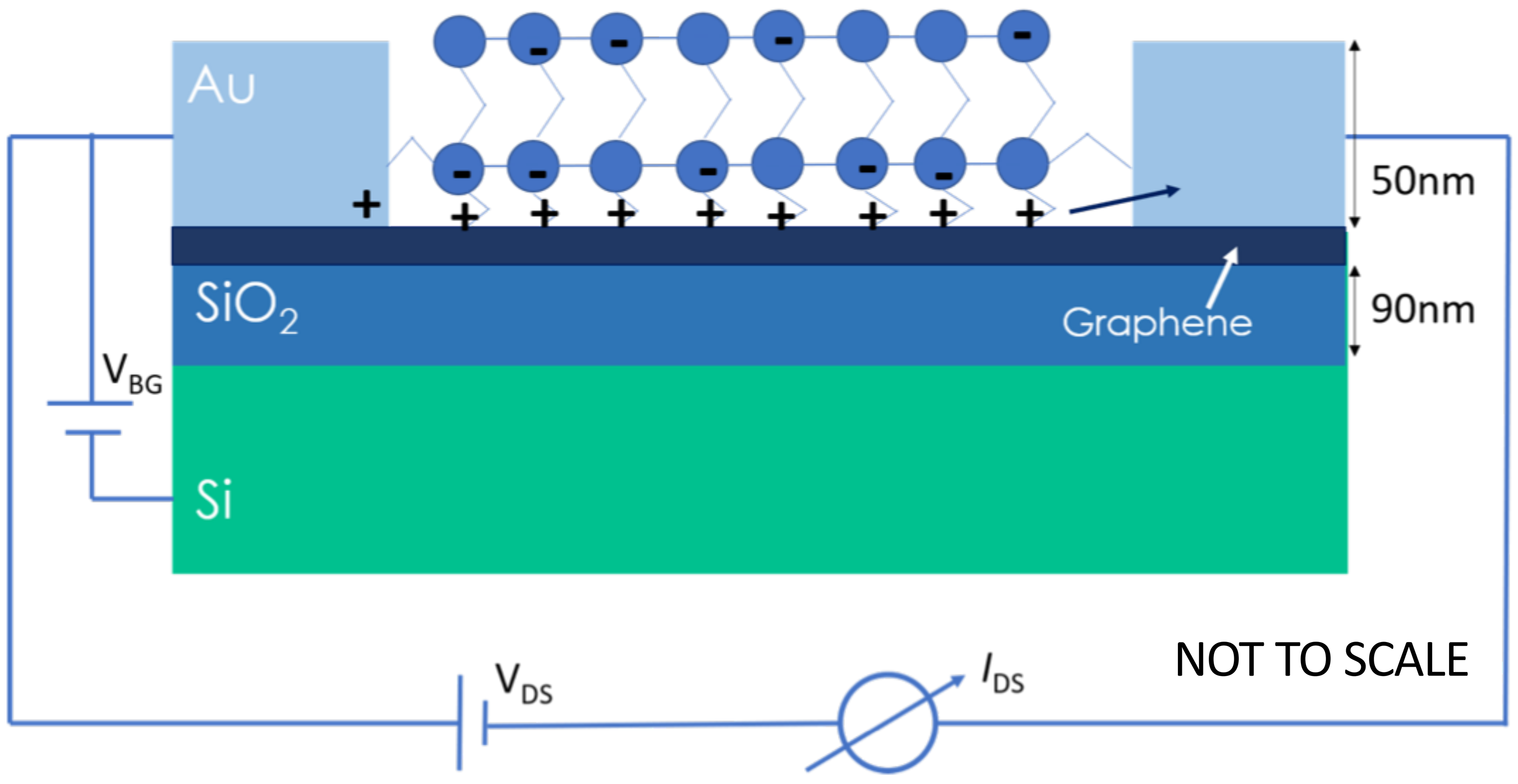
Introduction

- Graphene provides excellent properties [1] for photodetection:
  - ✓ Ultra-high mobility
  - ✓ Ultra-wide spectral range of absorption
  - ✓ Fast response times
- However, the use of graphene, alone, can not take advantage of this theoretical ultrahigh performance due to:
  - × An absence of an inherent gain mechanism [2]
  - × Graphene's absorbance of only 2.3% of incident light [3]
- A hybrid structure of graphene covered in nitrogen doped graphene quantum dots on SiO_2/Si with Au contacts was used to introduce a gain mechanism into a graphene-based photoconductor.
- This achieved a responsivity of 10^2 A W^{-1} and a gain of ~ 10^7 electrons per photon, consistent with literature [4] [5] [6].

Hybrid structure mechanism of gain



- The n-doped graphene quantum dots absorb incident photons generating electron-hole pairs (excitons).
- These excitons are transferred to the single layer graphene (SLG), in which they recirculate many times due to high charge carrier mobility of the SLG and the long trap-charge lifetime in the quantum dot layer. [4] [7]

References

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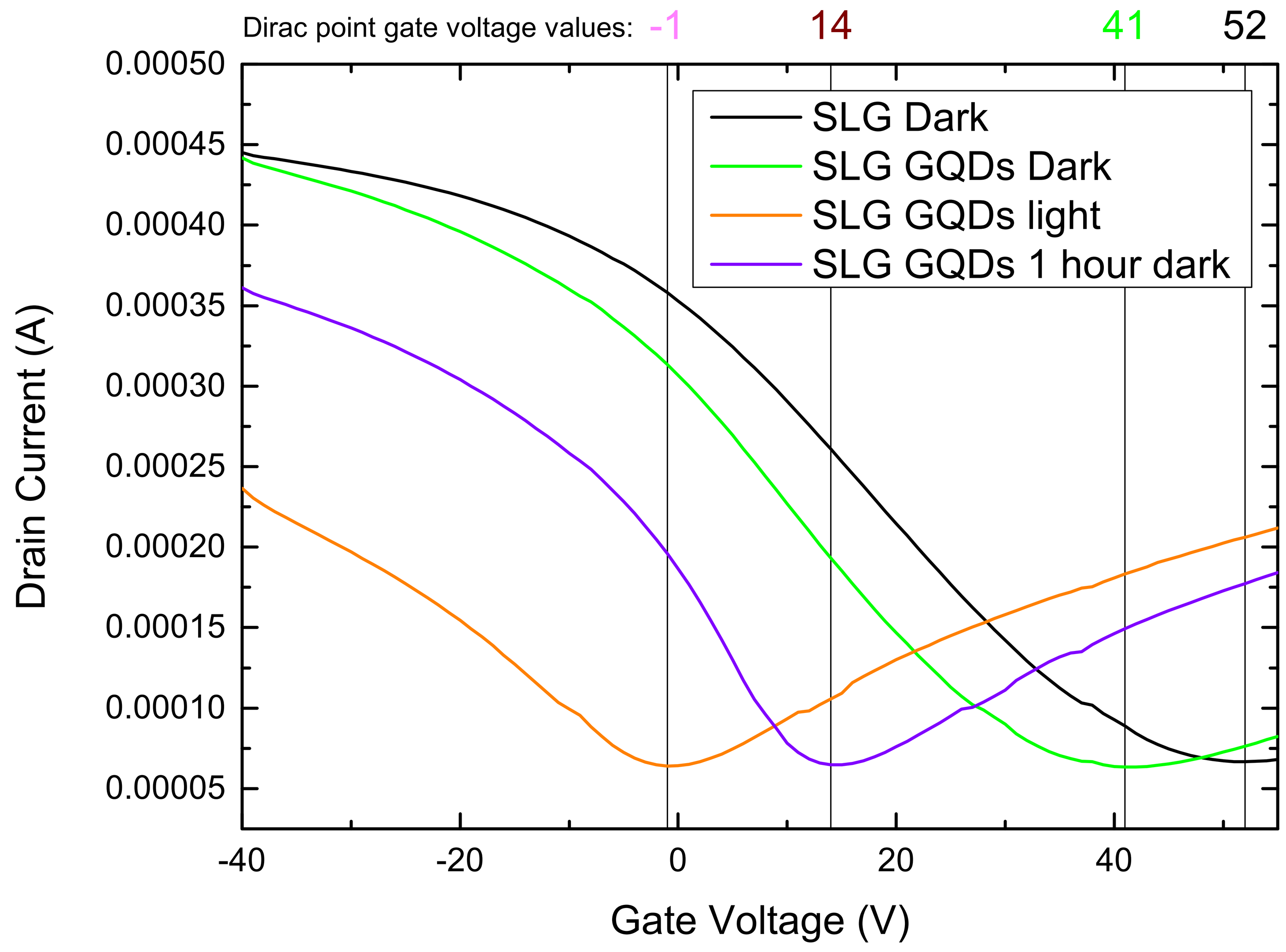
Dopant interference

- The SLG produced is found to be hole-doped, with the hole mobility of SLG one order of magnitude greater than the electron mobility.
- Therefore, **holes are the majority charge carrier in the SLG**.
- The subsequent deposition of GQDs upon the SLG generates a built-in electric field between the two layers due to the difference in the Fermi levels (and therefore workfunctions) of the individual materials. Due to the negative shift of the Dirac point (seen in figure below) between SLG dark and SLG GQDs dark, it is clear that the workfunction of the GQDs is higher than than the SLG. Therefore, **this indicates electron transfer from the GQDs to the SLG.**
- The **increase of electrons** in the SLG **causes a decrease of the hole concentration** giving a proportional **decrease of the current response** measured upon illumination.



Future Work

The next stages of further work on the hybrid graphene-quantum dot-graphene based photo- conductors should involve:

i. Synthesise n-doped SLG to match the doping of the GQDs to allow for maximum positive performance. Otherwise, synthesise p-doped GQDs to match the doping of the SLG to maximise performance. Compare which doping provides the highest performance and investigate why.

ii. Achieve a full benchmark of the photoconductor performance, by calculating the noise-equivalent-power and the specific detectivity of the hybrid photoconductor. [9]

iii. Investigate the effect of bilayer graphene where it could be theorised that the opening of a band gap could lead to higher sensitivity and suppression of graphene's large dark current. [10]

Acknowledgments

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