Graphene and MoS_2 ink formulation for fully-inkjet-printed heterostructures

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Motivation

- Printed **heterostructures** act as device platforms.
- **Inkjet-printing** technology provides **scalability** for mass-production of **inexpensive** device arrays in **any geometry**.
- **Stable jetting**, **adequate substrate wetting** and **uniform material deposition** with 2D material inks are required.

Ink formulation

Starting materials (Commercial **graphene** and **MoS_2** powders)

+

Polymer (PVP for graphene) + solvent (2-Butanol + IBA)

Surfactant (STDC for MoS_2) + water

Dispersion → **Ultrasound** / **Bath sonication** → **Centrifugation** → **Graphene ink**

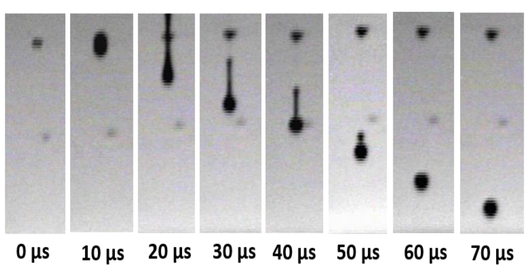
Centrifugation → **Solvent exchange** → **2-Butanol + IBA** → **MoS_2 ink**

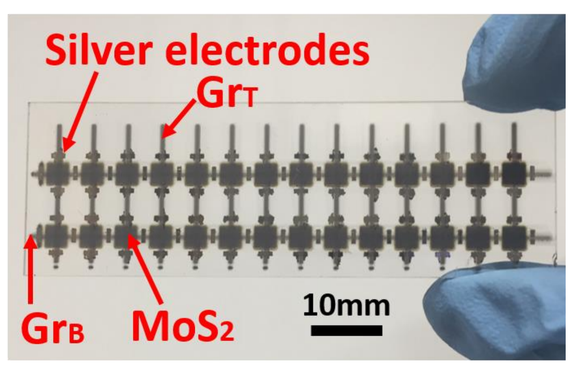
*IBA: Isobutanol, PVP: polyvinylpyrrolidone, STDC: sodium taurodeoxycholate.

Inkjet printing

- Ink rheology shows **good jetability** and **wettability** of inks, and it is confirmed experimentally.
- **$Gr_T/MoS_2/Gr_B$ heterostructure arrays** were printed on glass.

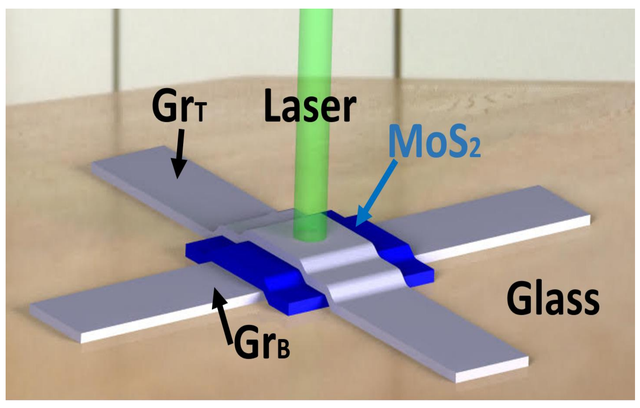
Inks	γ (mJ/m^2)	θ_c (deg)	η (mPa s)	ρ (g/ml)	Z
Gr/2-Butanol/IBA/PVP (9/1)	22.22±0.59	28.44±0.54	~4.86	~0.79	~4
MoS_2/2-Butanol/IBA (9/1)	22.16±0.4	29.72±0.18	~5.64	~0.77	~3

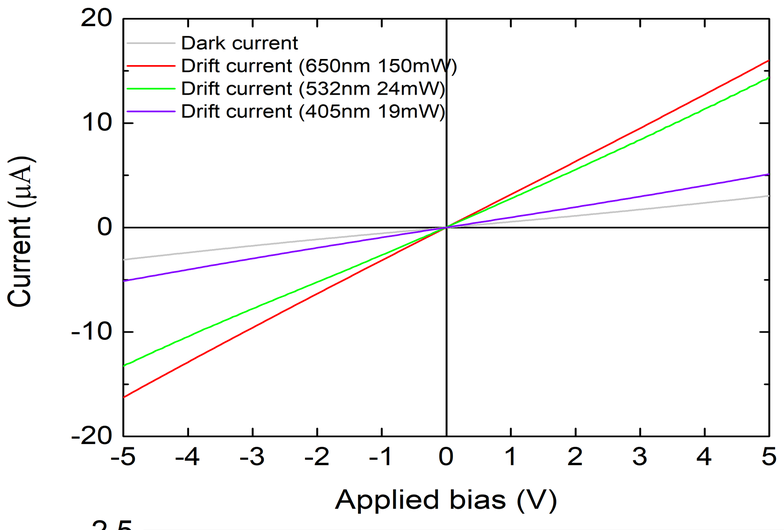


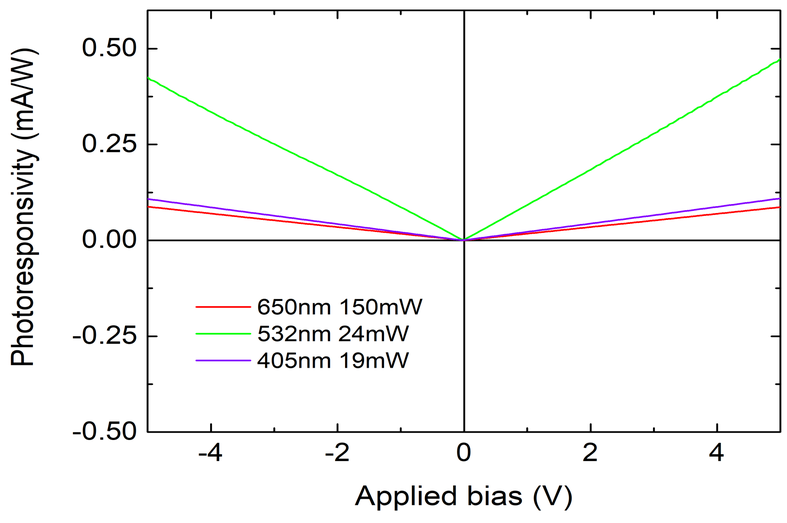


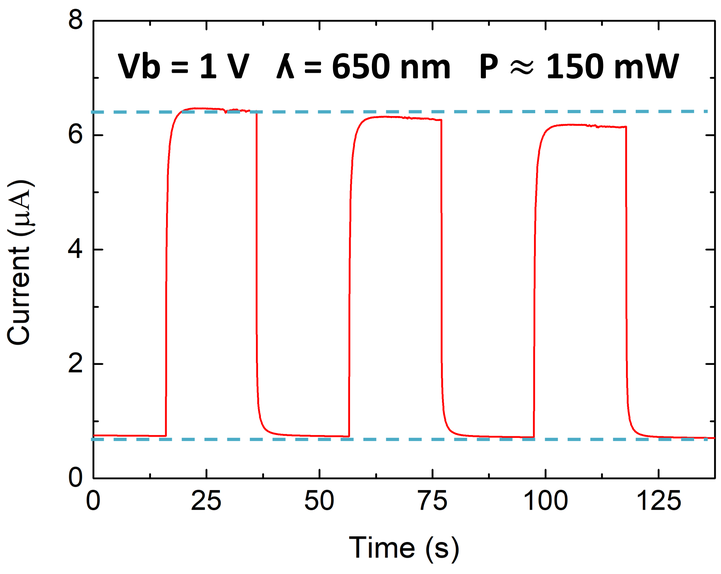
Devices

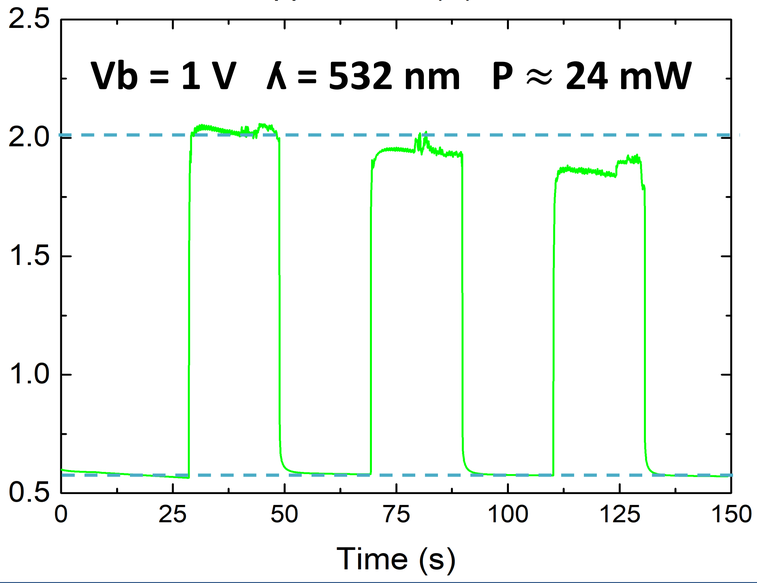
- Devices achieved a photocurrent of **1.4µA**, on-off ratio over **4** and photoresponsivity up to **0.1mA/W** at an applied bias of 1V and laser power of 24mW, well above the state-of-art literature results (~0.13µA, 1.5, 0.01mA/W, respectively [1]).

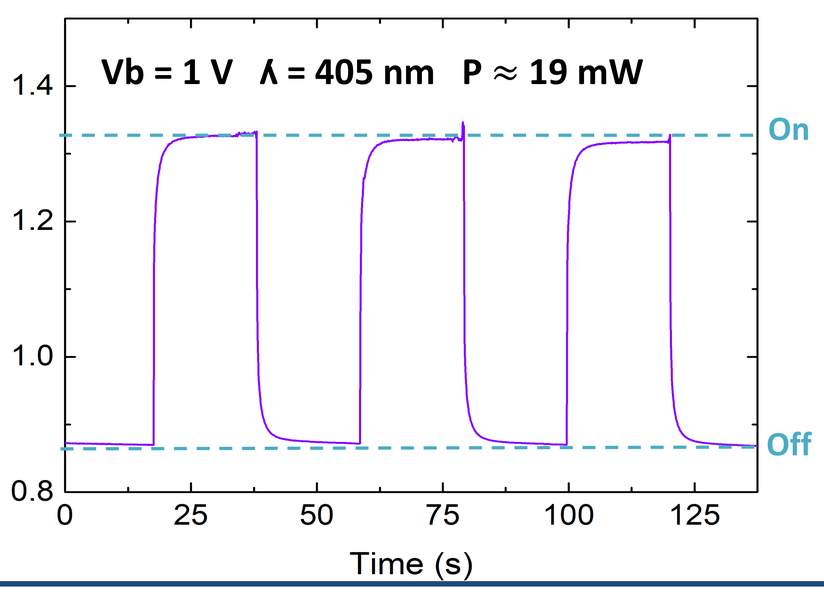












Summary

- Solvent composition of 2-Butanol and IBA (9/1) for graphene and MoS_2 achieved high concentrations up to 1 and 0.5mg/ml, respectively, as well as good jettability, stability and substrate wettability.
- $Gr_T/MoS_2/Gr_B$ heterostructures as photodetectors achieved competitive photocurrent, responsivity and on-off ratio.

References

[1] D. McManus, *et al*., Nature Nanotechnology, 12, 343-350, (2017).

Acknowledgments

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