Optimization of Carbon Ink for Reducing Critical Materials Usage in Semiconductor Devices

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Introduction

Carbon has been heralded as a replacement to critical material-based electrodes, such as silver, for semiconductor devices. The carbon ink consists of different forms of carbon and binders, which all contribute toward the effectiveness and production of the semiconductor.

Methods

- For this research, the carbon ink consists of graphite (GR) and carbon black (CB) for electrode conductivity.
- It also consists of ethyl cellulose (EC) and alpha-terpineol (AT) for the binding and adhesion of the ink[1].
- Isopropyl alcohol (IPA) was used to dilute the ink to a desired viscosity.

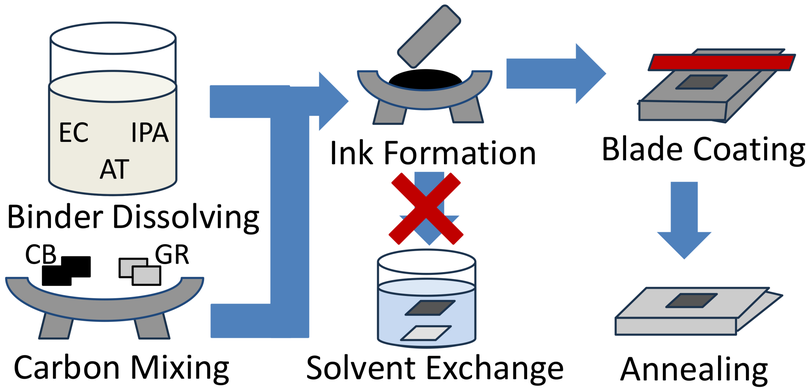

Figure 1: Formation of the carbon ink and film process.

Results

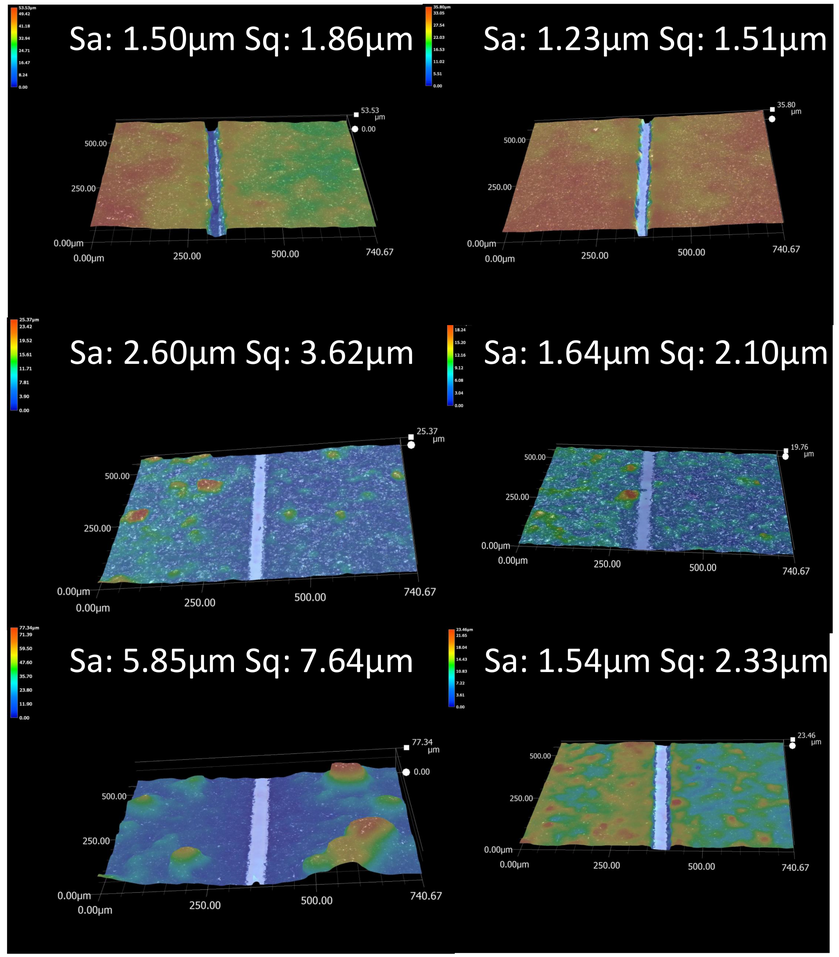

Figure 2-7: Three-dimensional surface profiles of 3:1:1 (standard), 6.75:2.25:1 (high GB/CB), and 3:1:2 (high binder) ratios, respectively (GR:CB:EC). As well as standard, 2:2:1 (high CB), and 1:3:1 (higher CB) ratios, respectively, using a denser CB (Images not to scale).

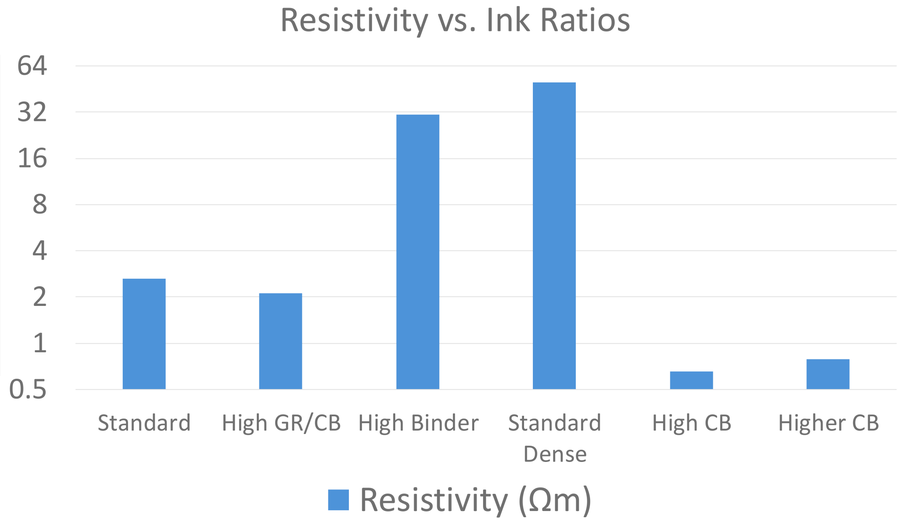

Figure 8: The resistivities of the different ink ratios.

Conclusion

- The 3D surface profiles show that more EC increases the roughness of the carbon layer, while more CB and GR increase carbon layer uniformity.
- Higher compositions of EC demonstrated higher resistivities, while more CB and GR resulted in lower resistivities.
- Increasing CB composition in comparison to GR was found to increase resistivity. Equal amounts resulted in a rougher carbon layer.
- For the next step, carbon modules will be compared with silver modules to further understand carbon's potential for replacing critical material-based semiconductors.

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References:
[1]Pourjafari, D., García-Peña, N. G., Padrón-Hernández, W. Y., Peralta-Domínguez, D., Castro-Chong, A. M., Nabil, M., Avilés-Betanzos, R. C., & Oskam, G. (2023). Functional materials for fabrication of carbon-based perovskite solar cells: Ink formulation and its effect on solar cell performance. Materials, 16(11), 3917. https://doi.org/10.3390/ma16113917

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