

# Accurate Measurement of Size of Graphene Oxide Flakes by Scanning Electron Microscopy (SEM)

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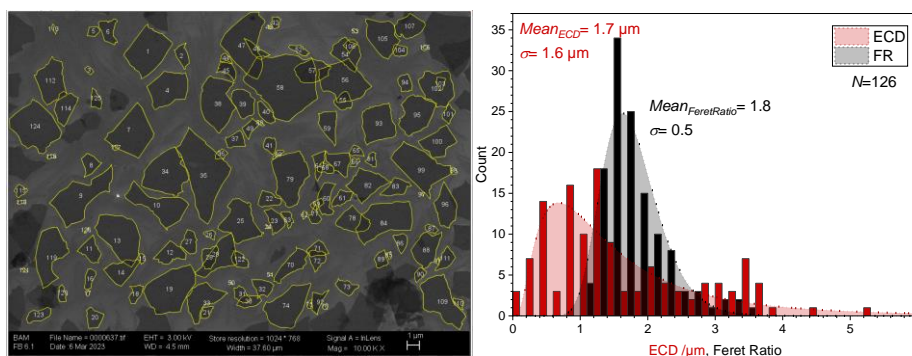
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Accurate characterisation of the morphology (size) and chemistry of graphene-related 2D materials (GR2M) is key in understanding their extraordinary functionalities [1]. Hence, not only the tailoring of these functionalities aiming at applications of increased-performance becomes possible, but also the correlation of the physico-chemical properties with the understanding of the potential toxicity eventually enables a safe and sustainable development of the GR2M for new applications [2,3]. Whilst AFM and Raman Spectroscopy are recommended to measure the thickness of GO flakes, Scanning Electron Microscopy (SEM) is the most suited method to assess their lateral size, which varies between tens of  $\mu\text{m}$  down to below 100 nm [4-6]. In this paper, procedures for the accurate determination of lateral size of graphene oxide (GO) flakes by SEM are presented. The prerequisite for accurate flake size analysis is the proper sample preparation, i.e. deposition of ideally isolated flakes on a substrate, with the flakes being unfolded, non-overlapped, parallel with the substrate, and having a high coverage density. Examples of optimum image caption conditions and image analysis procedures will be presented. The size descriptors and their measurement are described in the context of the corresponding analysis approach: i) length and width of the flakes with a quick and rough, but robust procedure, and ii) exact contouring of the flakes as part of a highly accurate, but more time-consuming measurement approach. The possibility of application of automated image analysis is discussed as the alternative to the manual flakes analysis.

## References

- [1] C.A. Clifford, E.H. Martins Ferreira, T. Fujimoto, et al., *Nat. Rev. Phys.*, 3 (2021) 233
- [2] V. Gies, S. Zou, *Toxicol. Res.*, 7 (2018) 93
- [3] Y. Li, H. Yuan, A.v.d. Bussche et al., *PNAS*, 110 (2013) 12295.
- [4] T. Bu, H. Gao, Y. Yao, et al., *Nanotechnology*, 34 (2023) 225702
- [5] K.K.H. De Silva, P. Viswanath, V. Kesava Rao, *J. Phys. Chem. C*, 125 (2021) 7791
- [6] G. Chemello G, X. Knigge, D. Ciornii, et al., submitted.

## Figures



**Figure 1:** SEM image after manual contouring of 126 graphene oxide flakes including their size measurement with ECD (equivalent circle diameter) and Feret ratio as selected size descriptors.