Fragmentation and exfoliation of low-dimensional materials; a statistical approach.

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Abstract

A main advantage for applications of Graphene and related 2-dimensional materials is that they can be produced on large scales by liquid phase exfoliation. The exfoliation process shall be considered as a particular fragmentation process, where the 2-dimensional (2D) character of the exfoliated objects will influence significantly fragmentation dynamics as compared to standard materials. Here, we used automatized image processing of Atomic Force Microscopy (AFM) data to measure, one by one, the exact shape and size of thousands of nanosheets obtained by exfoliation of an important 2D-material, Boron Nitride, and used different statistical functions to model the asymmetric distribution of nanosheets sizes typically obtained. Being the resolution of AFM much larger than the average sheet size, analysis could be performed directly at the nanoscale, and at single sheet level. We find that the size distribution of the sheets at a given time follows a log-normal distribution, indicating that the exfoliation process has a "typical" scale length that changes with time and that exfoliation proceeds through the formation of a distribution of random cracks that follow Poisson statistics.

References

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Figures

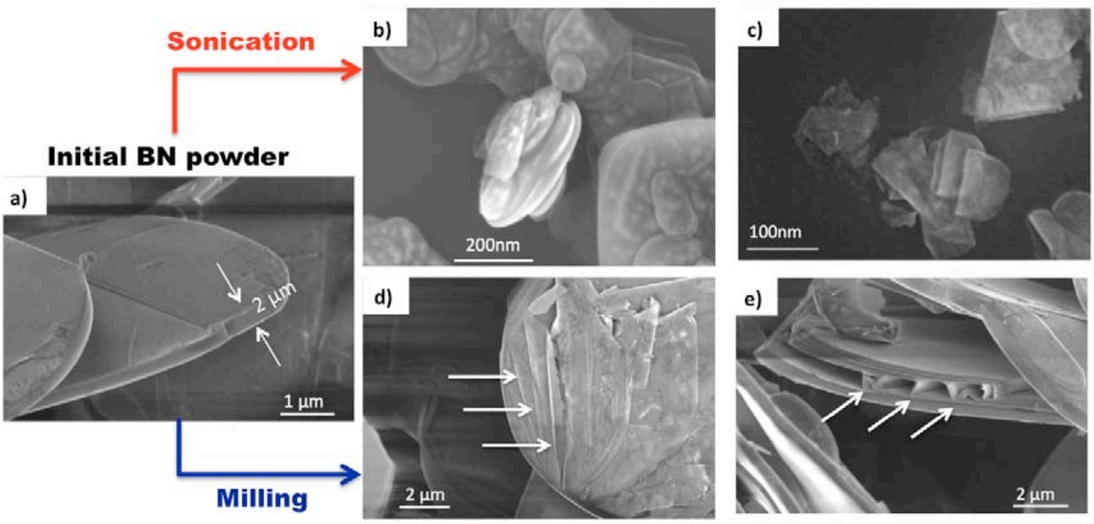

Fig. 1 SEM images showing the effect of different forces in BN exfoliation by milling and sonication

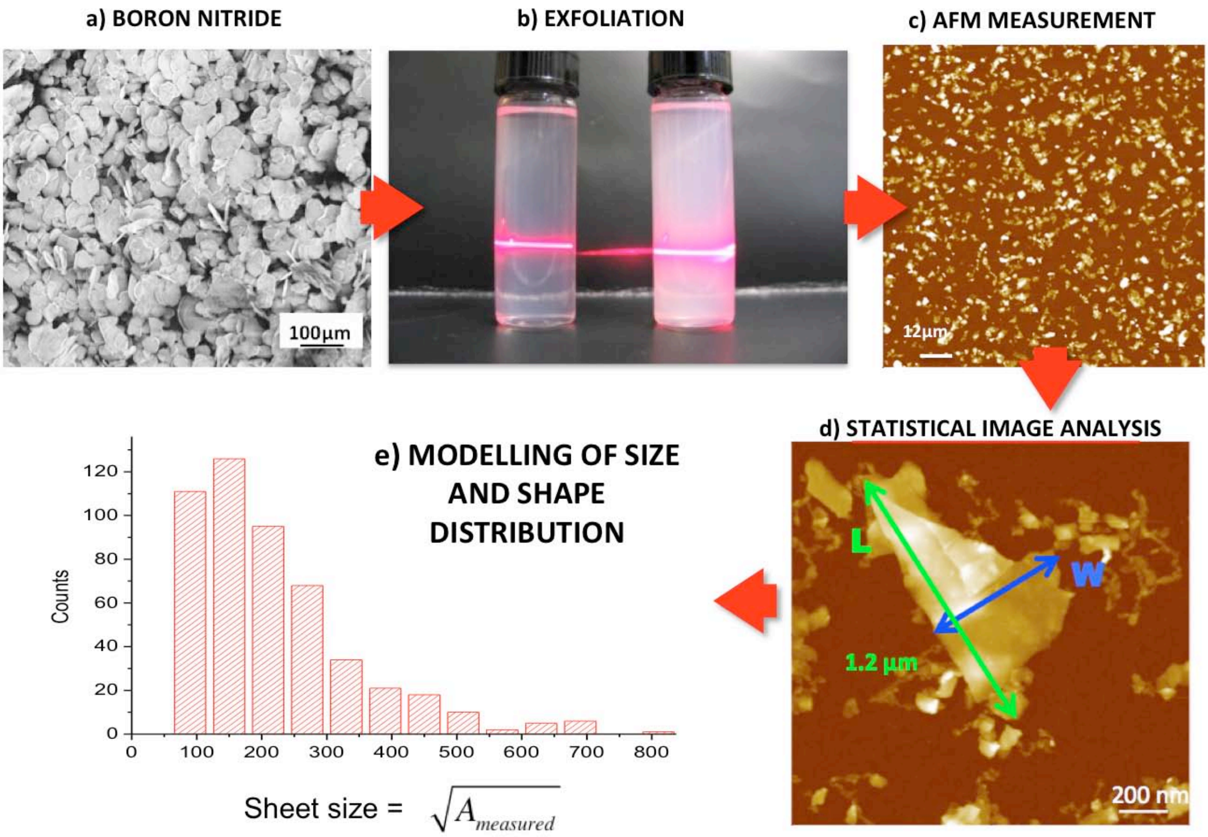

Fig. 2 a) SEM image of the pristine BN flakes used for exfoliation. b) Exfoliated solutions of BN in isopropanol, showing strong scattering due to the dispersed flakes. c) AFM image of BN nanosheets spin coated on silicon oxide substrates. d) Zoom-in of a single nanosheet, showing the typical, non-exact way to estimate its length and width. e) Histogram distribution of sheet size obtained instead measuring precisely the area of each sheet.