Integrating van der Waals materials-based devices on paper for electronics and optoelectronics

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Abstract

Paper-based electronics are anticipated to play a key role in the next generation of low-cost functional devices due to their lightweight, flexible and biodegradable features.[1] Benefiting from these features of paper as a substrate and the excellent mechanical, electronic, and optical properties of van der Waals (vdW) materials, many efforts have been devoted to integrating vdW material-based devices onto paper.[2] One of the main challenges by far is the development of an eco-friendly and cost-efficient fabrication technique. Recently, an emerging all-dry abrasion method is proposed to deposit a continuous and dense film on paper by simply abrading the layered vdW crystals on a rough paper surface. The resulting abrasion forces interrupt the weak interlayer vdW interactions, thus cleaving the crystals into micro platelets. In our work, we illustrate the general character and application potential of this method by fabricating films of 39 different vdW materials, including superconductors, semi-metals, semiconductors, and insulators, on common cellulose paper. We comprehensively investigate their optical characteristics demonstrating their exceptional optical quality: the absorption band edge of semiconducting vdW materials, as well as excitonic features in some vdW materials with high exciton binding energy, can be easily resolved. We also measured the electrical resistivity obtaining extremely low values that are orders of magnitude lower in some cases than those reported for analogous inkjet-printed films. We finally fabricate a variety of high-performance vdW material-based electronic and optoelectronic devices such as field-effect devices with the paper substrate as an ionic gate, strain sensors, paper cantilevers, and broad-band photodetectors.[3,4]

References

[1] A. Mazaheri *et al*. Nanoscale 12 (2020), 19068-19074
[2] S. Conti *et al*. Nature Communications 11 (2020), 3566
[3] W. Zhang *et al*. Applied Materials Today 23 (2021), 101012
[4] W. Zhang *et al*. Sensors and Actuators A: Physical 332 (2021), 113204

Figures

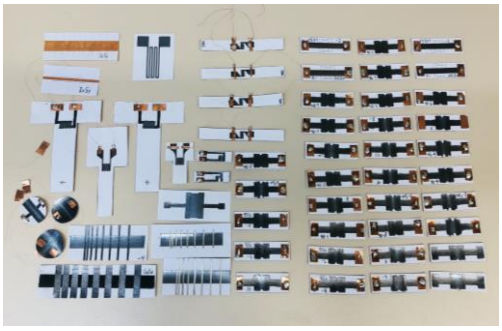

Figure 1: Picture of several integrated van der Waals materials-based devices on paper.