Efficient and Scalable Production of Anisotropic 2D Material Films for Electronic Applications

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Anisotropic 2D materials, such as black phosphorus (BP), exhibit unique direction-dependent properties, making them highly promising for optoelectronic and quasi-1D applications[1]. However, scalable fabrication of large-area anisotropic films remains challenging. While chemical vapor deposition (CVD) enables precise thickness control and crystal orientation[2], its high-cost limits widespread adoption. We introduce a roll-to-roll mechanical exfoliation[3] method that enables the scalable production of large-area anisotropic films while preserving crystal orientation. Linear dichroism measurements confirm that BP flakes maintain their intrinsic anisotropic properties across the film. To demonstrate the practical applications of this approach, we fabricated a directional electronic sensor, showing a strong correlation between film orientation and conductivity. This method offers a cost-effective and efficient route for integrating anisotropic 2D materials into next-generation electronic and optical devices.

References

[1] Fengnian Xia, Han Wang & Yichen Jia Nature Communications 5, 4458 (2014)
[2] Honglin Chen, Shan Jiang, ACS Nano, 2024,18,51,35029-35038
[3] Yigit Sozen, Juan J. Riquelme & Andres Castellanos-Gomez, Small Methods, Volume 7, Issue 10

Figures

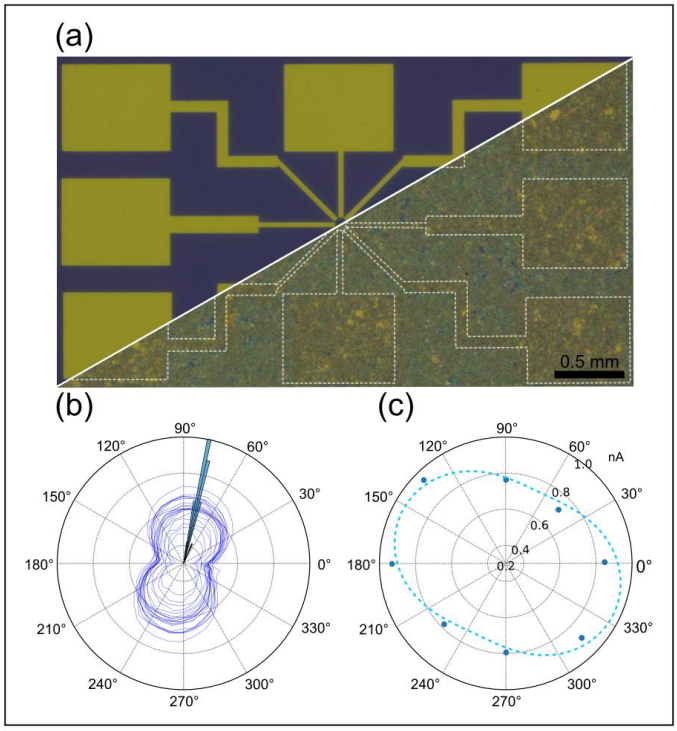

Figure 1: We analysed the anisotropic conductivity of BP films using a circular device with eight gold electrodes separated by 45°. Transmittance measurements on the BP film before transfer identified its armchair orientation. After transferring the film onto the device, current measurements at 1 V revealed a peanut-shaped anisotropic response, confirming higher conductivity along the armchair direction. These results validate the roll-to-roll exfoliation method for preserving and exploiting BP's intrinsic anisotropy in electronic applications.