# NANO HIGHLIGHT

## Nano-Manufacturing of Crumpled Graphene for Advanced Electronics

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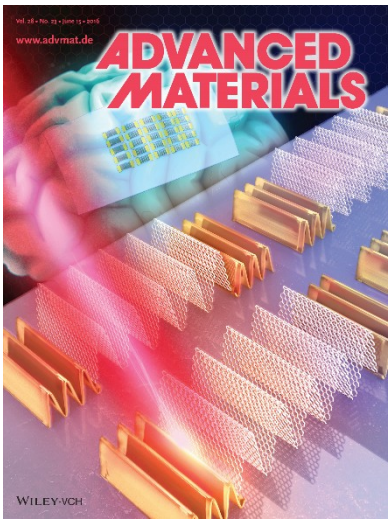
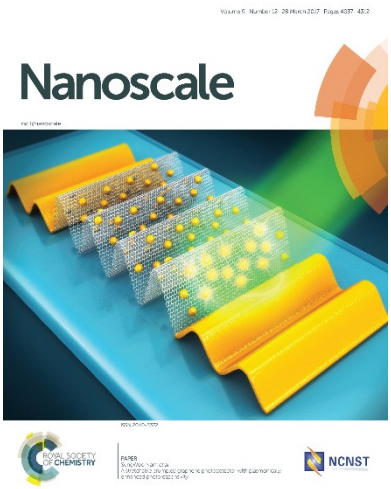
Inspired by the folds of an accordion, a new nano-manufacturing approach has been developed to enhance the light absorption and stretchability of atomically thin two-dimensional (2D) materials by surface topographic engineering using only mechanical strain [1]. This highly flexible system has the potential for wearable technology and integrated biomedical optical sensing technology.




Graphene has been extensively investigated in advanced photodetectors for its unique combination of broadband absorption, superb electronic properties, and mechanical flexibility. The light energy is absorbed by graphene and converted into electricity at the graphene surface, and the intensity of light is measured by the electric current level. However, owing to graphene's low optical absorptivity, graphene photodetector research so far has focused on hybrid systems to increase light absorption which require complicated integration processes and compromised performance.




Folding graphene like an accordion contributes to graphene based photodetector in two ways, increasing light absorption of graphene by areal densification and introducing stretchability up to 200% of its original length. Furthermore, unlike semiconductor-based photodetector, the graphene based photodetector offers a broadband detection, which means no limit on the detection wavelength. The photosensitivity of crumpled graphene photodetector shows 400% higher than flat graphene photodetector [2]. This approach to enhancing light absorption by crumpled structures can be universally applied not only to graphene, but also to other emerging 2D materials.

The photosensitivity is further enhanced by adding plasmonic nanoparticles (i.e., gold nanoparticles). Gold nanoparticles hold light around themselves, and the light absorption of graphene can be increased even higher. The increased light absorption leads the enhanced photosensitivity of the photodetector. Finally, the photosensitivity of crumpled graphene-gold nanoparticles photodetector shows almost 1200% higher than flat graphene photodetector [3].

**References**

[1] For further information about this project link to http://nam.mechse.illinois.edu or email swnam@illinois.edu.
[2] P. Kang, M. C. Wang, P. Knapp, and S. Nam, "Crumpled Graphene Photodetector with Enhanced, Strain-tunable

and Wavelength-selective Photoresponsivity," *Advanced Materials* **28**, 4639 (2016).
[3] M. Kim, P. Kang, J. Leem, and S. Nam, "Stretchable Crumpled Graphene Photodetector with Plasmonically-enhanced Photoresponsivity," *Nanoscale* **9**, 4058 (2017).