Hoop compression driven instabilities in spontaneously formed multilayer Graphene blisters over a polymeric substrate*

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Abstract

The blistering of elastic membranes is prone to elastic-solid as well as substrate-based mechanical instabilities. The solid-based instabilities have been well-explored in the mechanically indented blisters of elastic membranes over the rigid/solid substrates, but an integrated study illustrating the underlying mechanism for the onset of solid as well as substrate-based instabilities in the spontaneous blistering of a 2D material is still lacking in the literature [1, 2, 3, 4]. In this article, an extensive experimental as well as analytical analysis of the spontaneous blister-formation in the multilayer graphene (MLG) flakes over a polymeric substrate is reported, which elucidates the involved mechanism and the governing parameters behind the development of elastic-solid as well as viscoelastic-substrate based instabilities (as shown in Figures 1 & 2). Herein, a 'blister-collapse model' is proposed, which infers that the suppression of the hoop compression, resulting from the phase-transition of the confined matter, plays a crucial role in the development of the instabilities. The ratio of blister-height to flake-thickness is a direct consequence of the taper-angle of the MLG blisters and the thickness-dependent elasticity of the upper-bounding MLG flakes, which shows a significant impact on the growth-dynamics of the viscous fingering patterns (viscoelastic-substrate based instabilities) under the MLG blisters [5].

References

[1] A Khestanova E, Guinea F, Fumagalli L, Geim A K and Grigorieva I V, Nature Communications, 7 (2016), 12587.
[2] Dai Z, Hou Y, Sanchez D A, Wang G, Brennan C J, Zhang Z, Liu L and Lu N, Phys. Rev. Lett., 121-26 (2018), 266101.
[3] Pandey M and Kumar R, Journal of Physics: Condensed Matter, 34 (2022), 245401.
[4] Ares P, Wang Y B, Woods C R, Dougherty J, Fumagalli L, Guinea F, Davidovitch B and Novoselov K S, Proceedings of the National Academy of Sciences, 118 (2021), e2025870118.
[5] Pihler-Puzovi´c D, Illien P, Heil M and Juel A, Phys. Rev. Lett., 108-7 (2012), 074502.
* Pandey M and Ahuja R and Kumar R, Nanotechnology, 2022, **DOI** 10.1088/1361-6528/acaf33

Figures

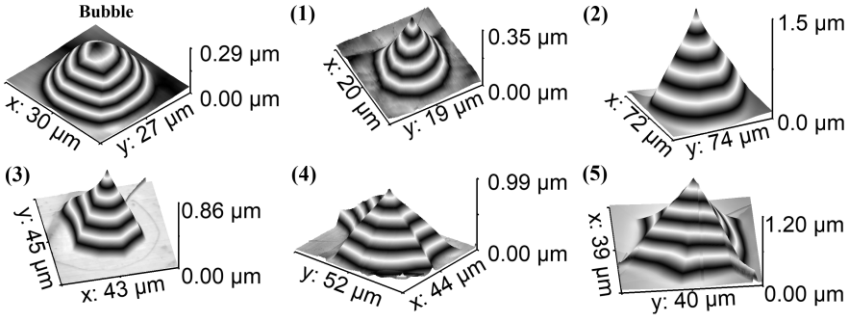

Figure 1: Reshaping of the MLG bubbles into the tent-like blisters as a result of the elastic-solid based instability.

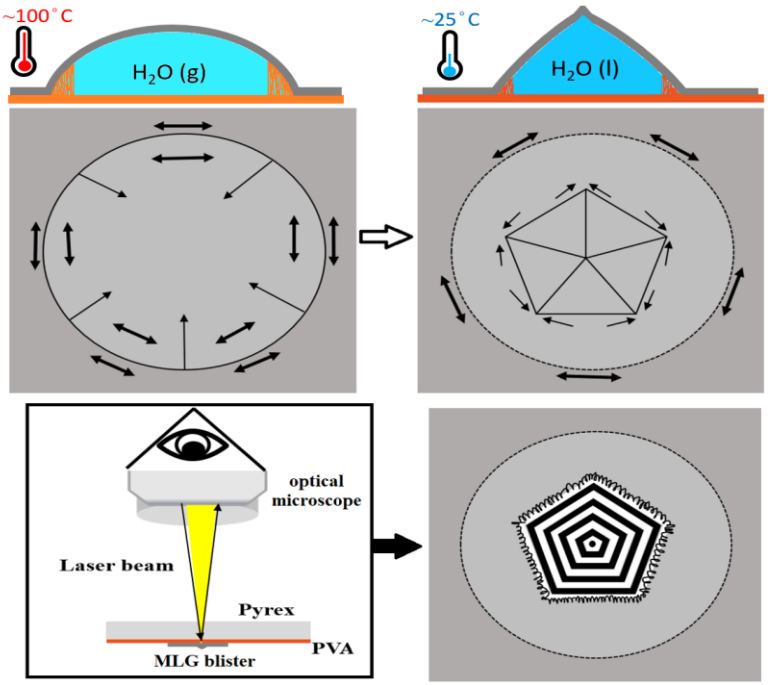

Figure 2: Schematic diagram depicts that the phase-transition induced hoop compression drives the elastic-solid as well as the viscoelastic-substrate based instabilities in the spontaneously formed MLG blisters.