Asymmetric Thermal Transport on Suspended Trapezoidal Graphene Channels

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With continuous development of electronic integrated circuits and systems along with device miniaturization, the heat dissipation has become an increasingly serious problem that restricts the high efficiency and longevity of computing systems. As a fundamental unit of the thermal management system, the thermal rectifier can be applied for active heat flow control [1], which works as an electrical diode. Regulating the thermal rectification (TR) of nanostructures is of great significance for heat dissipation applications [2]. Multiple physical mechanisms, such as the overlap of phonon spectra [3] and the phonon edge scattering effect [4], have been proposed to improve the understanding of the thermal rectification phenomenon in asymmetric nanostructures. We have recently developed two types of asymmetric graphene channel structures: trapezoidal [5] and half nanomesh [6] structures aiming to study their asymmetric thermal transport properties. By using the half-nanomesh channel, we have observed remarkable rectification at low temperatures with the rectification ratio up to 60 % [6]. However, the physical mechanism behind rectification and a guiding principle have not been clarified yet to achieve the room temperature operation with a practical useful rectification ratio.

In this project, we focus on the trapezoidal type and have designed a systematic way to change the shape, for investigating the influence of the scattering angle on asymmetric thermal transport. The devices were firstly measured at low temperatures to identify the key factor that can improve the thermal rectification ratio. It is of great significance to extend the application to room temperature or even higher temperatures.The device fabrication is based on graphene NEMS technology [7]. A series of trapezoid GNRs have been made with only changing the upper base length, from 1.0 um to 0.4 um. The lower base is all 1.2 um and the height of the trapezoidal channel is all 500 nm, as shown in Figure 1. By using the “differential thermal leakage measurement method” [5], a higher thermal ratification ratio was observed on the shorter upper base devices at 150K. It shows a potential way to develop a high-performance thermal rectifier with this kind of sample structure.

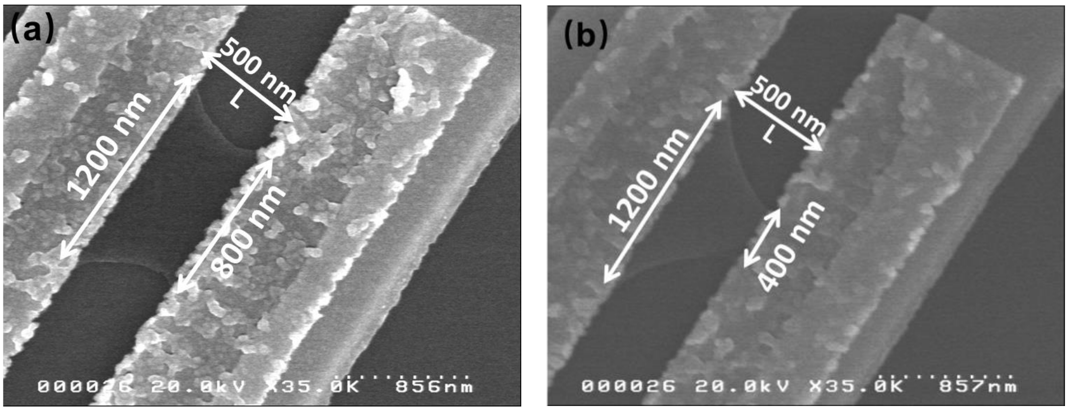

Figure 1. *(a) The left side of this trapezoid is 1.2 um and the right side is 0.8 um. (b) The left side of this trapezoid is 1.2 um and the right side is 0.4 um. The height of both trapezoids is 500 nm.*

References

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