Heat flow in nanomaterials is an important area of study, with both fundamental and technological implications. We developed a substrate-supported thermometry platform to measure thermal transport in graphene (Figure (a)). We find that the thermal properties of graphene can be tuned in sample sizes comparable to the phonon mean free path (mfp) [1]. Short, quarter-micron graphene samples reach ~35% of the ballistic thermal conductance limit [2] up to room temperature (Figure (b)), enabled by the relatively large phonon mfp (~100 nm) in substrate-supported graphene. In contrast, patterning similar samples into graphene nanoribbons (GNRs) leads to a diffusive heat flow regime that is controlled by ribbon width and edge disorder (b). In the edge-limited regime, the thermal conductivity scales with width as ~W^{1.8 ± 0.3}, being about 100 Wm-1K-1 in 65-nm-wide GNRs, at room temperature (Figure (c)). These results are the first demonstration of how the manipulation of two-dimensional device dimensions and edges can be used to achieve full control of their heat-carrying properties, approaching fundamentally limited upper or lower bounds.

![Figure (a): False-colored scanning electron microscopy image of parallel heater and sensor metal lines on top of an array of graphene nanoribbons (GNRs). Inset shows atomic force microscopy image of GNRs. (b) Thermal conductance per cross-sectional area (G/A) vs. temperature for our GNRs (L ≈ 260 nm, W as listed), a “short” graphene sample (L ≈ 260 nm, W ≈ 12 μm), and a “large” graphene sample from Seol et al.3 (L ≈ 10 μm, W ≈ 2.4 μm). The short but wide graphene sample attains up to ~35% of the theoretical ballistic heat flow limit2. (c) Thermal conductivity reduction with width for GNRs, all with L ≈ 260 nm, showing a scaling of ~W^{1.8±0.3} in the edge-limited regime.]