Thermal expansion coefficient of graphene measured by electron diffraction

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Graphene is a promising material for next generation electronic devices. Many studies of the thermal expansion coefficient (TEC) of graphene have been done because thermal expansion is crucial when designing graphene-based devices [1], [2]. However, the results are still controversial. Here we measured TEC of graphene using electron diffraction pattern in a transmission electron microscope (TEM).

Single-layer graphene was transferred onto TEM Mo grids with holey carbon support film (Quantifoil, diameters of holes: 1 m, using poly(methyl methacrylate) support method [3]. The diffraction patterns were collected in a Hitachi H9500 with a Gatan heating holder operated at 300 kV. When the film temperature was below 300 °C, the observed area of graphene contaminated resulting in irreproducible measurement. Therefore, graphene was heated inside TEM column at 400 °C before starting experiment to remove contaminants from the graphene transfer processes and to prevent beam-induced contamination. Ten diffraction patterns were collected with exposure time 2 s at 50 to-100 °C interval between 400 C and 900 °C.

The measured TECs of pristine samples that were heated for the first time have larger variations than the consecutive measurements of the same samples left in the microscope vacuum overnight. The results suggest strain between graphene and the carbon support film affects the measured TEC value. The TEC of the samples that heated two or more times was $\sim 3 \times 10^{-6}[K^{-1}]$.

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