# Investigation of Cu-incorporated Carbon Nanofibers Structural Transformation at High Current Flow by *in situ* Transmission Electron Microscopy.

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**Introduction:** Over the past few decades, carbon nanomaterials such as carbon nanofibers (CNFs) and graphene have attracted intense scientific interest due to its magnificent properties [1, 2]. Much of the research on graphene have been directed towards the exploration of the method to synthesis high quality and large area of graphene. Among the promising methods are pulse laser deposition and chemical vapour deposition. Whilst significant strides have been made in understanding graphene synthesis, their formation mechanism is not well understood. Recent advances in *in situ* techniques now open up the new possibility of studying solid phase interaction at atomic level. Here we report the direct observation of copper-incorporated carbon nanofibers (Cu-CNFs) structural transformation to graphene by in situ transmission electron microscopy (TEM).

**Experimental:** Cu-CNFs were fabricated using Kaufmann-type ion gun (Iontech. Inc. Ltd., model 3-1500-100FC). The samples used were commercially available graphite foils with dimension 5x10x100 µm. The edge of graphite foils stacks were irradiated with 1 keV $Ar^+$ ions at room temperature by continuous supplying of Cu during the CNFs growth. The details for the growth mechanism of ion-induced CNF have been described elsewhere in detail [3]. The Cu-CNFs then was mounted on cathode microprobe in TEM (JEM2010, JEOL Co., Japan) operated at 200 kV and the structural transformation of Cu-CNFs to graphene was investigated during current-voltage (I-V) measurement.

**Results and Discussions:** During I-V measurement, the high temperature was obtained by Joule heating in the structure of Cu-CNFs. Joule heating of Cu-CNFs results in the graphitization of their surface, and finally in the transformation into heavily distorted graphene. TEM images indicate that initially, the CNFs was amorphous in nature and the current flow in the I-V process induces the dramatic change in the crystalline structure of the CNFs, forming thin layer of graphene (1-3 layers). As a results, the electrical properties of the structure was improved where the current produced was remarkably increased, that is 1000 times higher than the initial value (from $10^{-8}$ to $10^{-5}$ A). The process proceeds with three steps: agglomeration of Cu nanoparticles, diffusion of amorphous carbon into Cu and the electromigration of Cu nanoparticles under further heating.

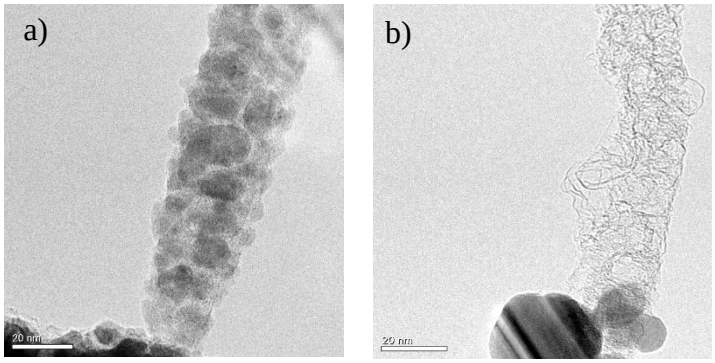


Fig. 1 (a) TEM image of Cu-CNFs before current flow. (b) TEM image of graphene formed after current flow.

**References:**

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