Aberration corrected STEM/ EELS study of morphology-composition correlations in nitrogen doped multi-wall carbon nanotubes

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Nitrogen is a good candidate to fit into the hexagonal carbon network due to its similar atomic size to carbon. Even though nitrogen doped carbon nanotubes (N-CNTs) have been studied so far in field emission, in situ electrical conductivity measurements, composites, dispersions and chemical sensing, we still have very limited understanding on their chemical and physical properties compared to their undoped counterparts.

This problem results from the fact that despite the large number of papers on N-CNTs, only a few of them validate the presence of nitrogen heteroatoms and report qualitative and quantitative analysis of the nitrogen content. Without investigating the concentration, the spatial distribution and most importantly the bonding type of nitrogen heteroatoms, we cannot efficiently exploit N-CNTs and N-CNTs applications remain a laboratory exercise.

Here, we have utilized electron energy loss spectroscopy (EELS) coupled with state-of-the-art aberration corrected scanning transmission electron microscopy (STEM) operated at 60 kV to investigate morphological and compositional variations in N-CNTs that we have synthesized by aerosol assisted chemical vapor deposition, from various C/N ratios. Three N-CNT morphologies occur and their distribution change in relation to C/N ratio used in the synthesis. Most importantly, we have found out that the nitrogen spatial distribution and concentration differ among morphologies, which gives us an insight on how to tune the properties of N-CNTs.