Vertical self-assembly of fullerenes via solvent vapor annealing process

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Vertically grown conducting or semiconducting low dimensional structures attract a great deal of interest not just for their wide range potential applications, but also for the fundamental understanding about the chemical forces involved in the energetically less favorable directionality. While there has been a significant progress in both demonstration and understanding for the vertical growth of inorganic materials, such as Si, Ge, ZnO 1D nanowires and ZnO, Ag, Co 2D nanoplates, not much is either known or demonstrated for organic molecule-based structures except carbon nanotubes.

In this presentation, successful formation of vertically self-assembled C_{60} 1D nanowires via solvent vapor annealing (SVA) process will be discussed. To induce vertical self-assembly of C_{60}, it turns out to be critical to choose 1) proper solvent that determines the dimensionality of resulting structure, and 2) appropriate environment under which solvent molecules are guided to exert maximum vertical directional force and minimum lateral directional force at the surface-liquid interface during evaporation, so that C_{60} molecules are guided to move along the vertical direction of evaporating solvent. By employing m-xylene as a solvent during the SVA process, we show that vertically self-assembled C_{60} 1D nanowires are obtained in high yield from dry C_{60} thin film that is pre-deposited on a Si substrate. The two critical roles of chosen solvent, i.e., determinations of shape and direction of the self-assembled C_{60} structures are further confirmed by switching the solvent to CCl_4 that is known to assemble C_{60} molecules into lateral 2D disk geometry when simply drop-dried from its solution. Upon the SVA process using CCl_4, vertical 2D disks are indeed formed from dry C_{60} film.

The structural characteristics of vertically grown C_{60} 1D wire and 2D disk are investigated by scanning electron microscopy (SEM), X-ray diffraction (XRD), and electron diffraction (TEM-SAED). The details about the proposed mechanism of the vertically self-assembled C_{60} nanostructures and more control experimental results will be also discussed.

References

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