The role of solutal instabilities in growth of high quality graphene and carbon nanotubes

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Growth of high quality graphene and carbon nanotubes requires higher temperatures in order to achieve higher degree graphitization and thereby crystallization. This in turn assumes exploitation of the liquefied substrate or catalyst particles respectively. Methods for growth of carbon nanotubes at high temperatures (1000-2000^{o}C) are well established, while growth of graphene from liquefied substrate has been reported only recently. Nevertheless despite significant progress the growth peculiarities are not fully understood yet and thereby control over the final product properties such as diameter/chirality for nanotubes, or domain stricture/topography for graphene still remains challenging. Here, the growth mechanisms of these carbon allotropes are analyzed as non-equilibrium processes based on Mullins-Sekerka and Benard-Marangoni instabilities in Me-C binary alloys. It appears that the wavelength of the solutal instability that defines density of domains on the surface of Me-C system can be used to control the grown carbon structures. These analyses offer parameters and relationships between them such as imposed temperature gradients, quenching rates, diffusion coefficients of carbon in the metal and the miscibility gap of the Me-C system that can lead to controllable growth of high quality carbon allotropes.