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Superior functionality and luminescence of nanodiamonds for sensoric and diagnostic applications by targeted high temperature gas-solid reactions and electron beam irradiation

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Nanodiamonds have excellent mechanical and optical properties, high surface areas and tunable functional surfaces. They are also non-toxic, which makes them well suited for biomedical applications. Here we highlight an integrated and scalable surface functionalization by a high temperature gas-solid phase reaction protocol monitored via thermogravimetry for very controlled and precise degraphitization, as well as hydrogen, oxygen and nitrogen (-NH2) functionalization in a high temperature reactor. In particular, we discuss the rational and precise control of chemical functionalization through introduction of functional groups and of an increased photoluminescence from additional nitrogen-vacancy defects (NV-centers) produced via controlled electron beam irradiation. We have shown that multiple surface analytical methods such as IR-, Raman, photoelectron spectroscopy, light scattering, and electron microscopies allow for quality control of the surface functionalization.

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(Non-van der Waal) Functionalization of graphene with retained trigonal lattice and charge carrier mobility

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To widen the spectrum of its applications, it is important to functionalize graphene, while preserving its superior properties, and retaining its planar lattice (for high mobility) and its carbons' sp2 hybridized state (for high carrier density). Such a functionalization mechanism, when conducted in compliance to the needs of semiconductor manufacturing processes will enable graphene's incorporation into diverse applications. Here, we develop a unique eta-6 organometallic approach to functionalize graphene in a vapor-phase process, which retains the structural and electrical properties, while offering chemical sites for interaction and interfacing with other chemical or biochemical systems. In contrast to other functionalization processes, the eta6-functionalized graphene maintained its high charge carrier mobility (1000 cm2V-1s-1 at 300 K). We will discuss the mechanism of charge transfer in eta-6 functionalization of chromium carbonyl on graphene. The chemical groups were utilized for subsequent chemistry via an *in-situ* formation of silver nanoparticles at functionalization sites. We show that this graphene-eta-6-Ag structure enables an ~11-fold plasmonic enhancement in the efficiency of graphene/n-Si solar cells (1.24%) to exemplify the potential of this functionalization. This process will unveil graphene's previously unknown potential to hierarchically interface with physical and biological components to produce novel systems and applications. Results will also facilitate gate-fabrication for FETs via atomic- layer-deposition (currently a major challenge).

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