Special Feature: Nanomaterials and Processing

Overview

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Global warming and air pollution have persisted as severe environmental problems addressed by academic, industrial, and governmental entities during the last few decades. To resolve such issues and realize an energy-saving, resource-conserving, and low-carbon society, nanotechnologies, which are key technologies both to synthesize and to fabricate nanomaterials and their applications through top-down and bottom-up processing, will play major roles. Distinctive and tunable optical, electronic, magnetic, and mechanical properties derived from nanoscale dimensions of nanomaterials and their very high surface-area to volume ratio offer great potential for drastically enhanced performance of optical, electronic, and energy conversion/storage devices, lightweight materials, various types of catalysts, and so forth. Particularly carbon nanotubes, nanosheets such as graphene, silicene, and two-dimensional transition metal dichalcogenide, and a wide variety of nanoparticles are anticipated as key materials for advanced applications. Belying their potential, no prospects for actual applications with nanomaterials have yet emerged, with a very few exceptions. One reason is that it is difficult to produce large amounts of nanomaterials with well-defined microstructures and properties. Therefore, mass production of high-quality, tailor-made, and inexpensive nanomaterials is widely viewed as the ultimate challenge of the next decade.

This special issue specifically examines our recent challenges related to nanomaterials and processing of four kinds: (i) unique nanographenes created using top-down solution processing, (ii) a solid-state exfoliation method for silicon-based nanomaterials, (iii) liquid-phase synthesis of copper (Cu) and nickel (Ni) alloy nanoparticles that serve as alternatives to Pb-rich solders, and (iv) laser ablation methods for colloidal nanoparticles. The first article reports novel nitrogen-functionalized graphene quantum dots with high photoluminescence efficiency and wide tunability of narrow photoluminescence lines. The article demonstrates potential applications as color conversion materials for white light-emitting diodes. The facile solid-state synthesis of Ca_xSi_2 material with slit-like nanopores and excellent anode performance for Li ion batteries composed of Ca_xSi_2 (Li storage sites)/Ni-silicide (conductive media) nanocomposites are presented in the second article. The pressure-free bonding technique presented in the third article uses nanoparticles formed by liquid-phase synthesis, with combinations of Cu nanoparticles, Ni-alloy nanoparticles, and Ni affinity layers. The last article describes surfactant-free noble metal nanoparticles such as Ag and Pd that are masterfully synthesized by laser ablation of each target powder in pure water.