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Graphene, polymers & advanced nano-materials

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This work deals with the metal nanoparticles (like copper, silver, lead nanopowders), metal oxide nanopowders, polymers, metal polymer nano-composites and advanced material like low cost graphene material. It also explains their vast range of novel nano-technological applications like nanofluids, heat transfer, solar panels, sensors, biotechnology, biomedical etc. Optical property like Surface Plasmon Resonance (SPR) and magnetic property like Superparamagnetism have major roles in nano-materials. SPR of nano-metallic surfaces is the incoming light results in a collective oscillation of the electrons at the metal's surface. This plasmonics phenomenon absorbs and intensifies light at specific wavelengths. It has many promising applications which can be exploited to transmit optical signals, to interact with bio-molecules and in solar cells. Exploitation of SPR increases the photon absorption and to improve efficiency/to achieve highly efficient solar cells. Particularly, plasmonic nanoparticles having quantum yield value more than one, is the best choice of material for solar cells. Superparamagnetism improves the accuracy of spintronic sensors because a small sensed field is sufficient to order the spins in a superparamagnetic material. Such improved and accurate sensors are useful in various industrial and biomedical applications. Innovations such as "World's first plant materials based superparamagnetic particles" can be utilized in cancer hyperthermia & imaging (MRI Contrast agent) applications. Advanced materials like Graphene and other nanomaterials are utilized in solar cells for harvesting and storage of energy. Large surface area, high surface-area-to-volume ratio and compatibility with flexible substrates of these materials make them as unique candidate for solar cells. Their incorporation in energy storage device such as super-capacitor (physical charge storage device having faster/ higher power density, lower energy density and lower internal resistance) provides balance between the energy storage and source.

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Multilayer nano BaTiO3/poly (vinylidene fluoride) thin film with high energy density

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Organic-inorganic 0-3 nanocomposites, which combine the potentially high dielectric strength of the organic matrix and the high dielectric permittivity of the inorganic filler, are extensively studied as energy-storage dielectrics in high-performance capacitors. To obtain high dielectric constants, a large volume fraction of the inorganic component is necessary, but this will frequently deteriorate the dielectric (breakdown) strength and thus limit the energy density value of the overall nano-composite. In this study, a gradated multilayer $BaTiO_3$/poly (vinylidene fluoride) thin film structure is presented as a means to achieve both higher breakdown strength and a superior energy-storage capability. Key to the process is the sequential deposition of uniform dispersions of the single component source, which generate a blended PVDF-BTO-PVDF structure prior to full evaporation of solvent and thermal treatment of the dielectric. The result is a 2-2 like sandwich structure with partial 0-3 character, seamless interfaces between layers and a concentration gradient of the BTO. The central layer designed to provide the high electric displacement, is composed of high volume fraction 6-10 nm BTO nanocrystals produced by a TEG-sol method. The outer layers of the structure are predominantly PVDF, with a significantly lower volume fraction of BTO, taking advantage of the higher dielectric strength for pure PVDF at the electrode-nanocomposite interface. The film is mechanically flexible, and can be removed from the substrate, with total thicknesses in the range 1.2-1.5µm. Parallel plate capacitance devices exhibit highly improved dielectric performances, compared to reported values for BTO-PVDF 0-3 nanocomposites, with low-frequency permittivity values of 20-25, a maximal discharged energy density of 19.4J/cm^3 and dielectric breakdown strengths up to 495kV/mm..

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