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Post-growth annealing techniques on removal of tellurium inclusions in cadmium zinc telluride crystals

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Nuclear radiation detectors are used for detecting, tracking, and identifying radioactive materials which emit high-energy gamma and X-rays. The use of Cadmium Zinc Telluride (CdZnTe) detectors is particularly attractive because of the detector's ability to operate at room temperature and measure the energy spectra of gamma-ray sources with a high resolution, typically less than 1% at 662 keV. While CdZnTe detectors are acceptable imperfections in the crystals limit their full market potential. One of the major imperfections are Tellurium inclusions generated during the crystal growth process by the retrograde solubility of Tellurium and Tellurium-rich melt trapped at the growth interface. Tellurium inclusions trap charge carriers generated by gamma and X-ray photons and thus reduce the portion of generated charge carriers that reach the electrodes for collection and conversion into a readable signal which is representative of the ionizing radiation's energy and intensity. One approach in resolving this problem is post-growth annealing which has the potential of removing the Tellurium inclusions and associated impurities.

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Nanocomposites at extreme (space) environment

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Polymer-based advanced composites always suffer from degradation at extreme temperature in the range between 220 and 77 K and low atmospheric pressure. Within this temperature range, composite structures behave very brittle and many micro-cracks are easily formed due to Differential Thermal Coefficients of Expansion (CTEs) between polymer matrix and high strength reinforcements. Besides, at the Low Earth Orbit (LEO) environment the structures may also be subject to damages due to meteoroid attack, in which many tiny particles left over from the formation of the solar system and they are travelling at very high speed to cause serious impact and abrasion onto the structures. Out-gassing and higher oxidation rate are also problems for polymers using at this environment. For atmospheric re-entry vehicles, due to their high speed return, the surface of the vehicles facing in the entry direction has to maintain its strength at very high temperature (~ 3500 K) when they are passing through the atmospheric layer within a short period of time. Different research works have been conducted to design ablators (Thermal Protection System, TPS) to minimize the weight and thickness of ablating, charring and pyrolyzing zones worldwide. Materials used for the ablators must efficiently cool the vehicles via energy absorption of the endothermic breakdown of the polymeric constituents, transpiration cooling as the pyrolysis gases percolate from the interior of the material to the surface, and re-radiation from the hot char layer that forms on the surface. The geometry of the re-entry shape can minimize the heat induced by controlling the form (blunt body theory) of shock wave. Therefore, studies on using nanoparticles to enhance the anti-cracking resistant properties and prolong the pyrolyzing process are necessary. Besides, due to the increasing use of polymer-based nanocomposites at extreme environment condition, their inspectability becomes a hot topic, at least in coming 5 years to explore more real-time or remote health monitoring techniques to ensure the safety of structures. Embedded sensors, self-healing technology and smart structure designs are most prominent research fields in nanocomposite structures. In this invited lecture, an overview on the nanocomposites, their mechanical, thermal and structural properties at different working environments is given. The following key items will also be introduced: (i) Design of the heat shield's geometry for re-entry vehicles; (ii) shock wave effect in relation to the heat transmission to the vehicles; (iii) advantage of using Phenolic Resin Carbon Ablator (PICA); (iv) types of nanoparticles for property enhancement for the vehicles and (v) possibility of using nano-particles (nanotubes, nanoclay, nano-silica, silica-aerogel, etc) to enhance the effectiveness of the pyrolyzing process of PICA to prolong the heat transfer. The potentiality of using different structural monitoring techniques to serve as the extreme environment will also be discussed.

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