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Assessment of Nanoparticle Dispersion Using a Novel Pulsed Laser-Induced Microthermography Technique

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Carbon-based polymeric nanocomposites combine low-cost polymers with high-performance carbon nanostructures like carbon nanotubes, nanoplates, and graphene. The addition of small amounts of these nanofillers enhances the material's electrical, thermal, and mechanical properties. However, achieving good dispersion and homogeneity of these nanofillers in the polymer is crucial for maximizing performance. Nanoparticles tend to self-aggregate, hindering their potential. Current methods to assess dispersion, such as TEM and SEM, are expensive and time-consuming, prompting the need for faster, non-destructive evaluation techniques. Methods like acoustic microscopy, dynamic scanning calorimetry, and infrared thermography are gaining attention for their efficiency. Active infrared thermography uses heat sources like flash lamps or pulsed lasers to detect thermal irregularities caused by filler dispersion. Pulsed laser thermography enhances sensitivity but has a limited field of view.

In this work an innovative non-destructive pulsed thermographic approach utilizing a nanosecond pulsed laser as a heat source is adopted for assessing the presence of nanoparticle aggregates in nanocomposites. Using a cooled infrared camera fitted with a macro lens to enhance the geometric resolution of the images (up to 6 microns), various dispersion levels of carbon nanotube (CNT) loaded epoxy resin nanocomposites were examined. The method significantly improves energy resolution by effectively utilizing the high energy flux injected by the laser in a short timeframe. Clusters with distinct shapes and sizes (as small as 30 microns) were spotted as being embedded in the matrix. This study marks a breakthrough in image quality and time savings for quick non-destructive assessments in nanostructured composite manufacturing. By integrating the inspection method with a robotized manipulator and by using intelligent image processing software, this approach would enable fast, remote, and detailed in-line quality control of large nanocomposite parts.

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