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Accurate And Refined Strain-Sensing Smart Skin (S4) And Its Advantages Over Digital Image Correlation For 2D Non-Contact Strain Mapping

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This study reports refinements to the recently developed "strain sensing smart skin" (S4) method and comparisons against the established digital image correlation (DIC) method on noncontact strain sensing. S4 uses single-walled carbon nanotubes embedded in thin polymer coatings as microscopic sensors. Strains in the specimen surface are transmitted to the nanotubes, causing systematic changes and spectral shifts in their near-infrared fluorescence signatures. Analysis of fluorescence spectra from S4 sensing films then gives local strain values based on noncontact optical measurements. In the current refinement, a dual-layer base coating with an opaque primer and a protection layer is included in the S4 technique to block intrinsic emission, provide a smooth surface for the sensing layer and protect the primer from sensing layer solvent damage. Tests were performed on acrylic, concrete and aluminum specimens that had been shaped and stressed to generate particular strain patterns. The strain maps measured with the refined S4 films were directly compared with DIC and finite element method (FEM). Those strain patterns presented by FEM simulations are more clearly revealed by S4 than DIC, particularly for sub-millistrain levels and on sub-millimeter length scales, which is critical in structural damage detection. These findings show the potential of S4 strain measurement technology as a promising alternative or complement to existing technologies for non-destructive evaluation and structural health maintenance.