Three-dimensional Super-resolution Crack Imaging in Industrial Manufactured Components: A Truncated Correlation Photothermal Coherence Tomography Approach

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The challenge of detecting cracks in powder metallurgy (PM) components has been a topic of interest for many years, with no practical commercial solution currently in place. In this study, we employed enhanced truncated-correlation photothermal coherence tomography (eTC-PCT) imaging to visualize 3D cracks within PM automotive parts. Through the application of effective diffusion reversal techniques, we restored blurred infrared photothermal images to their original optical resolution. This approach allowed for the creation of 2D depth-resolved photothermal tomographic images and 3D cross-sectional mapping of cracks. This technique reveals the precise spatial dimensions of surface and subsurface cracks, reaching depths that conventional thermal imaging cannot access due to limitations imposed by the depth-integrated nature of conventional thermal-wave imaging, properties of PM materials, and the physics of spreading diffusion. Diffusion reversal imaging holds the potential for further development as a non-destructive tool for enhancing quality control and feedback mechanisms in the metal forming process of green automotive parts.