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Compton Imaging Tomography for Nondestructive Evaluation of Spacecraft Thermal Protection Systems

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Novel nondestructive evaluation (NDE) systems based on a recently pioneered Compton Imaging Tomography (CIT) technique ^[1-4] are currently being developed by Physical Optics Corporation (POC). CIT provides high-resolution, three-dimensional, Compton scattered X-ray imaging of the internal structure of evaluated objects, using a set of acquired two-dimensional, Compton scattered X-ray images of consecutive cross sections of these objects. Unlike conventional computerized tomography, CIT requires only one-sided access to objects, has no limitation on the dimensions and geometry of such objects, and can be applied to large, multilayer, nonuniform objects. Also, CIT does not require any contact with objects during its application.

Currently POC is developing a CIT-based tool that addresses NASA's need for NDE of lightweight, rigid, and/or flexible ablative materials (PICA, Avcoat, AETB, etc.), and provides noncontact, one-sided *in situ* operation for accurate detection, identification, and precise spatial localization and measurements of internal and surface defects (cracks, voids, delaminations, porosity, and inclusions), and evaluation of bondlines and in-depth integrity of such materials and also large-area multilayer thermal protection system (TPS) structures with complex geometries. The feasibility of the tool was successfully demonstrated in NDE of various TPS samples provided by NASA. This tool can detect individual internal defects with dimensions about 1 mm³, and bondline defects less than 6 mm by 6 mm by the thickness of the adhesive of ≤ 100 μm . Also, it can detect anisotropy of the TPS materials. It also allows precise detection of flaws and in-service damage for ceramic, metal matrix composite, textile polymeric, aluminum/ titanium materials/structures, providing quantitative information on residual structural performance. The current scanning speed of TPS structures is about 2.5 min/ft² (25 min/m²): ~ 250 ft² of an entire Orion TPS can be scanned in 10-12 hr.

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