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Correlative Microscopy for Aviation and Aerospace

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Correlative microscopy (CM) workflows allow and aid solving a broad range of scientific and industrial problems (e.g. battery research, 3D printing, smart materials, integrated circuits, multi-physics simulation, etc.) previously unreachable by the typical experimental operando. CM workflows involve coordinated in 2D / 3D space and time (temporal 4D imaging) characterization of materials and components across a range of length scales. Various apparatus and imaging modalities contribute to the workflow, for example light, electron/ion microscopy, X-Ray computed tomography (CT), SIMS, EBSD, EDS, WDS, CL, XPS, Raman, STEM and TEM imaging and metrological techniques. These techniques use advanced cross-platform sample holders and dedicated software for automatic or guided coordinate transfer and locking solutions. CM delivers plethora of coregistrated 3D data that is often post-processed by artificial intelligence (AI) algorithms. AI-based segmentation or complex, multi-phase microstructures reduces the time-to-results from months to days or even dozens of hours. Further CM is often followed by an image-based modelling and multi-physics simulations.

As a practical example of CM for aerospace and defense industries we study a thermal barrier coating (TBC) used in the afterburner liner of turboramjet configured JT11D-20 engine (Fig. 1). The CM workflow used in this study correlates 3D data from HeliScan micro CT, femtosecond Laser Plasma FIB-SEM serial sectioning tomography across the length scales required to characterize and understand effects of long-term service on microstructural characteristics of the TBC (Fig. 2). Each system contributes structural (micro CT, Serial Sectioning) and analytical (EBSD, EDS) data directly within its characteristic length scale. The Laser Plasma DualBeam, cross-platform holder kit, Maps and Avizo software also plays a key role in integrating the workflow across the full range of length scales. Atomic scale S/TEM imaging and quantitative analysis is a logical extension of the workflow to the nano scale.

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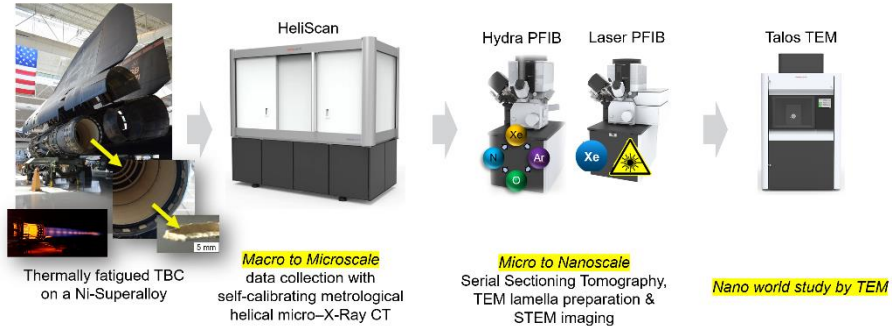

Fig. 1: Shows the experimental workflow.

Fig. 2: Shows composite image of multi-scale and multi-modal data collected from the TBC sample.