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Tackling Materials Failure: Scale Bridging for Structural Integrity

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Message from the Guest Editors

As the Second Law of Thermodynamics suggests, failure is an intrinsic characteristic of any materials system. Given its prevalence, one would assume that assessing a materials system's capability to endure is relatively straightforward; however, this is not the case. The proverbial *butterfly effect* is an appropriate moniker for failure as delicate and pernicious events rooted in the lower-length scales can evolve almost unpredictably to severely compromise the structural integrity of a materials system. For example, in metallic systems, seemingly innocuous dislocations at the atomic scale can evolve into life-limiting cracks in a myriad of ways. Some dislocations might nucleate microcracks whose stress intensities are amplified by micron-sized voids, thereby facilitating ductile crack propagation. Others might initiate microcracks that evolve synergistically with oxidation, creep, and/or fatigue loading. In organic materials systems, physiological processes, such as the up-regulation of proteins (e.g., in cell membrane repair), can act to strengthen or even heal the system, making the question of failure both stochastic and highly non-linear.

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Message from the Editor-in-Chief

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