Probing Complexity in Nonequilibrium Materials Processing*

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Materials processing is an inherently nonequilibrium procedure if physical changes of significance are to be realized. Variations in the degree of complexity associated with processing and the extent of departure from equilibrium required to achieve desired technological results are limited only by processing technology and imagination. On the other hand, our understanding of the underlying science associated with materials processing and our ability to predict *a priori* the outcome of materials processing steps outside envelopes of known practice are remarkably limited. In fact, our ability to predict the outcome of highly nonequilibrium processing steps from first principles (even *a posteriori*) is severely limited. This relegates most materials processing advances to "search and discovery" methods. Discovery is great when it happens, but it relies on serendipity and becomes increasingly rare in complex and mature technologies. This talk will underscore the charge of Focus Panel 2: Controlling the Dynamics of Materials Processing, through nonequilibrium materials processing examples (e.g. pulsed laser film growth, plastic deformation, displacement cascade radiation damage, pulsed laser/ion processing, …) on short and long time scales in which detailed knowledge and fundamental understanding are limited at least in part by available high temporal and spatial resolution probes of materials structure, microstructure, evolution, and dynamics. The critical importance of identifying needed probe capabilities and experiments to team with, test, and extend increasingly powerful computational materials structure and dynamics capabilities will be discussed, along with emphasizing the importance of identifying and projecting key experiments and probe characteristics required to address the complexity associated with nonequilibrium materials processing beyond present theory and computation envelopes.

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