# Computational design of materials processes

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A framework for the computational design of materials processes will be discussed and mathematical techniques will be introduced that allow the design of processes that result in products of desired shape and material properties.

In the context of deformation process design, we will present a mathematically rigorous parameter and shape sensitivity analyses for large deformations of hyperelastic-thermo-viscoplastic materials using an updated Lagrangian framework. Weak sensitivity equations are derived from the partial differential equations that result by differentiating the governing continuum equations of the direct thermomechanical analysis with respect to design variables such as the preform shape or the die surface in a given forming stage. The continuum sensitivity analysis is performed in an infinite-dimensional continuum framework that accounts for the non-differentiable nature of the frictional and contact conditions. Examples will be shown of the design of multi-stage deformation processes that result in products of desired shape and material state with minimum material utilization rates and energy.

In the context of solidification and crystal growth process design, we are developing functional optimization techniques to control the various physical mechanisms that implicitly define the type and length scale of the obtained solidification microstructures. Our control is obtained with proper design of the furnace conditions, application of external magnetic fields and other. A number of examples in directional solidification process design will be presented.

In closing, we will briefly review some of our current activities in real-time robust control of materials processes, modeling of uncertainty to allow an accelerated materials and process insertion, and introducing multiple length scale computational design models for explicit modeling and control of microstructures.