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Measurements and Inverse Modeling of Cure Shrinkage in Filled and Unfilled Epoxies

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Volume shrinkage during cure significantly impacts residual stress in potted components. To deal with this manufacturing issue, our long term vision is to improve the providence of our in-house non-linear viscoelastic curing constitutive models that will be used to directly simulate manufacturing stresses in a finite element analysis (FEA) setting. These simulation tools may help improve future cure schedules and material selection.

There are many hurdles in realizing this vision: challenges in resolving and modeling reaction kinetics of different epoxies, representing modulus evolution during the curing process, evolving the stress free shape of a material with simultaneous deformation and network evolution, and modeling the cure shrinkage strains throughout the reaction process. In this talk, we will focus on recent efforts to use an unconfined bi-layer beam geometry, isothermal Differential Scanning Calorimetry Data, and shear modulus evolution data to estimate the volume shrinkage in Epon 828 DGEBA / DEA filled with forty percent by volume glass micro balloons. The simplicity of the geometry admits a straightforward and fast procedure for estimating the volume shrinkage outside of an FEA setting. The method works reasonably well while the material remains rubbery, but as it enters the glass transition, curing continues with additional beam deflection, which currently is not considered in the model.

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