2015 Track and Symposia: Track 2
Challenges in Mechanics of Time-Dependent Materials

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Sponsored by:
SEM Time Dependent Materials Technical Division
and Composite, Hybrid and Multifunctional Materials
Technical Division

This track spans three full days of the conference with 10 sessions and addresses time and rate-dependent behavior of all materials, including: metals, biomaterials, polymeric materials, composite and organic materials; effect of harsh environments and varying length scales; constitutive modeling and modeling of the mechanics of processing/fabrication of all materials. We are pleased to feature four distinguished keynote speakers in the sessions: Dr. Robert Chambers, Professor Nancy Sottos, Dr. Allan Zhong, and Professor Isaac Daniel. We will hold our second annual student paper competition.

Papers dealing with modeling and experimental aspects of the subject area were sought. A wide range of topics were solicited and organized. Papers in the following general technical research areas are included:

- **Metallic and Polymeric Materials**
  - Effects of Extreme Environments including Temperature, Radiation Resistance, Damage, Degradation and Aging
  - Challenges in Time-dependent Behavior Modeling of Low, Moderate and High Strain Rates
  - Effects of Inhomogeneities on the Time-Dependent Behavior

- **Composite, Hybrid and Multifunctional Materials**
  - Challenges in Time-dependent Behavior Modeling Viscoelastoplasticity and Damage
  - Effects of Interfaces and Interphases on the Time-Dependent Behavior

- **Mechanics of Materials from Advanced Manufacturing, including Additive Manufacturing**
  - Property characterization from AM
  - Process modeling and simulations of AM
  - Material design using AM

- **Time-dependent Effects at Variable Length Scales**

The Time Dependent Materials Technical Division is sponsoring the second annual best student paper for papers presented in Track 2.

The track organizers thank the presenters, authors and session chairs for their participation and contribution to this track. The support and assistance from the SEM staff is also greatly appreciated.
Glass forming materials like polymers exhibit a variety of complex, nonlinear, time-dependent relaxations in volume, enthalpy and stress, all of which affect material performance and aging. Durable product designs rely on the capability to predict accurately how these materials will respond to mechanical loading and temperature regimes over prolonged exposures to operating environments. This cannot be achieved by developing a constitutive framework to fit only one or two types of experiments. Rather, it requires a constitutive formalism that is quantitatively predictive to engineering accuracy for the broad range of observed relaxation behaviors. Moreover, all engineering analyses must be performed from a single set of material model parameters. The rigorous nonlinear viscoelastic Potential Energy Clock model and its engineering phenomenological equivalent, the Simplified Potential Energy Clock model, were developed to fulfill such roles and have been applied successfully to thermoplastics and filled and unfilled thermosets. Recent work has provided an opportunity to assess the performance of the SPEC model in predicting the viscoelastic behavior of an inorganic sealing glass. This presentation will overview the history of PEC and SPEC and describe the material characterization, model calibration and validation associated with the high Tg (~460°C) sealing glass.

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Track 2: Keynote Presentation
Allan Zhong—Halliburton
Challenges for High-pressure High-temperature Applications of Rubber Materials in the Oil and Gas Industry #242
Wednesday, June 10, 2015 | Session 45

As wells are drilled deeper and deeper offshore, the reservoir temperature will become hotter, and the downhole pressure will become higher. The high pressure high temperature (HPHT) conditions in a deep-water well poses significant challenges for both metallic and nonmetallic materials. These challenges are especially serious for rubber and other polymer-based materials due to the significant degradation of the material properties.

In this presentation, a broad overview of the challenges for applications of rubber and other polymer-based materials in downhole tools that are subjected to HPHT environments will be presented along with the current approaches being taken by the industry to address these challenges.

The need for new material development as well fundamental understanding of rubber mechanics under HPHT conditions will also be discussed.

Track 2: Keynote Presentation
Isaac Daniel—Northwestern University
Failure Criteria of Composite Materials Under Static and Dynamic Loading #487
Wednesday, June 10, 2015 | Session 59

To facilitate and accelerate the process of introducing, evaluating and adopting of new material systems, it is important to develop/establish comprehensive and effective procedures of characterization, modeling and failure prediction of structural laminates based on the properties of the constituent materials, e.g., fibers, matrix, and the single ply or lamina.

A new failure theory, the Northwestern theory, has been proposed for predicting lamina yielding and failure under multi-axial states of stress including strain rate effects. It is primarily applicable to matrix-dominated interfiber/interlaminar failures. It is based on micromechanical failure mechanisms but is expressed in terms of easily measured macroscopic lamina stiffness and strength properties. It is presented in the form of a master failure envelope incorporating strain rate effects.

The theory was further adapted and extended to the prediction of in situ first ply yielding and failure (FPY and FPF) and progressive failure of multi-directional laminates under static and dynamic loadings. The significance of this theory is that it allows for rapid screening of new composite materials without very extensive testing and offers easily implemented design tools.