**Objectives**

- Develop multiple cross-validated test procedures to identify time-dependent behavior of compliant TIMs
- Build generalized model appropriate for input into FE codes
- Validate the developed model with test data

**Approach**

**Experimental Background**

- Microscale Tester Capability
- Dynamic and Relaxation Testing

**Theoretical Background**

Proney Series: $G(t) = G_n + \sum_{i=1}^{\infty} G_i e^{-t/\tau_i}$

In a generalized Prony series notation of $G(t)$,

- $G_i = G_n + \sum_{i=1}^{\infty} G_i \omega_i^2$,
- $G_n = \sum_{i=1}^{\infty} G_i \omega_i^2$

Storage Modulus: $G_i = \frac{\varepsilon_n}{\varepsilon_0} \cos \delta$

Loss Modulus: $G_n = \frac{\varepsilon_n}{\varepsilon_0} \sin \delta$

**Results**

**Effect of Strain on Moduli**

- Loss Modulus negligible compared to storage modulus

**Effect of Frequency on Moduli**

- Reasonable range of frequencies for thermal cycling

**Model Building**

- Theoretical background: Prony Series: $(G(t) = G_n + \sum_{i=1}^{\infty} G_i e^{-t/\tau_i})$

**Impact**

- Detailed viscoelastic models developed (ready for use in FE codes)
- Prony series parameters identified for VO Ultrasoft, 2500S 20
- Storage modulus for VO Ultrasoft, 2500S20 and NTP characterized
- Moduli values from Prony series data validated using dynamic test results
- VO Ultrasoft preferable to Gap Pad 2500 (higher conductivity to modulus ratio)
- NTP-2 is $10^3$ times stiffer than VO Ultrasoft but practically elastic in behavior
- Storage shear modulus approximately 0.005 Gpa

**Future Direction**

- Carry out relaxation tests for NTP-2 to validate dynamic tests and understand anisotropic effects
- Study the effect of temperature on thermal and mechanical degradation
- Study the effect of stiffness of TIM material to stress and life of solder joints
- Understanding the impact of heat sink attach pressure on solder joint failure

**Acknowledgements**

The authors are grateful to CTRC, Delphi, Intel and Toyota for their support.