



Laboratory: Structural Design & Analysis Lab.



Department of Mechanical and Energy Engineering
 Advisor: Chao Yung-Ching Assistant Professor .

Teaching Courses: Statics, Dynamics, Semiconductor Process

Research Interests: Semiconductor process, Advance PKG, CAE Analysis

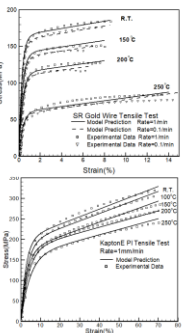
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Research Topic:

A: Property characterization for advanced semiconductor & PKG material

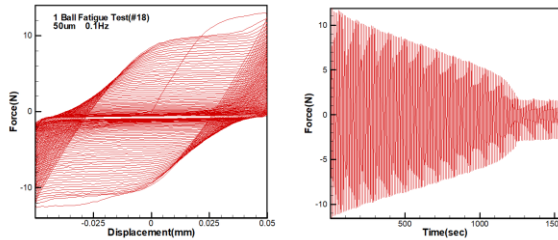
B: Advanced semiconductor process development



25µm Gold Bonding Wire
 $\sigma = \frac{E_0}{k}(1 - e^{-k\epsilon}) + E_1\epsilon(1 - T^2)$
 $k = 1 - \beta \log\left(\frac{\sigma}{E_0}\right)$
 Published in "Journal of Electronic Materials", Vol. 32, No. 5, pp159-165, 2003
 $E_0(T) = 166.572 - 0.4267 + 3.646 * 10^{-3} T^2$
 $E_1 = 250 \quad \beta = 0.04$
 $\alpha(T) = 369.719 - 0.3587 + 5.216 * 10^{-3} T^2$

Kapton-E polyimide film
 $\sigma = E_0(1 - e^{-\alpha\epsilon}) + E_1\epsilon(1 - T^2)$
 $E_0(T) = 204.37 - 0.149T - 9.79 * 10^{-3} T^2$
 $E_1 = 187.0813 - 3.624 * 10^{-3} T - 9.87 * 10^{-3} T^2$
 $\alpha(T) = 39.58 - 0.0478T - 9.569 * 10^{-3} T^2$

Single Solder Ball/Bump Fatigue Test
 Ball Diameter = 760µm Ball Height = 400µm
 0.1Hz Total Displacement Range 10



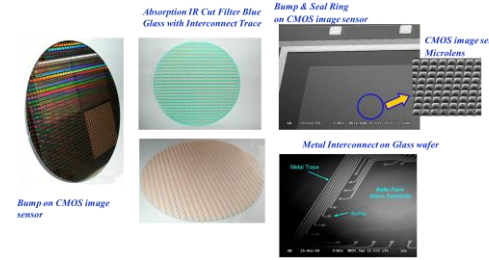
Force vs. Displacement

Force vs. Time

- What's new in voltage regulator (VR)
 - Discrete component → on substrate → on-chip
 - Planar spiral type → multi-layer stacking
 - Magnetic material (NiFe? CoZrTa? CZTB?)
- Challenge
 - Device performance ← → Material ← → Process
 - Process complexity/compatibility/manufacturability
 - Hetero interface issue
 - KPI?
- KPI
 - Precisely process & stress control

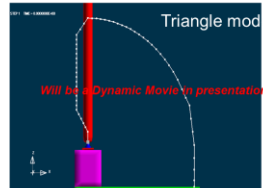
Current State of Inductor Based VR Technology

Company	Product	Power	Efficiency	Size
TI	TPS5430	1.5W	90%	1.5mm x 1.5mm
TI	TPS5431	1.5W	90%	1.5mm x 1.5mm
TI	TPS5432	1.5W	90%	1.5mm x 1.5mm
TI	TPS5433	1.5W	90%	1.5mm x 1.5mm
TI	TPS5434	1.5W	90%	1.5mm x 1.5mm
TI	TPS5435	1.5W	90%	1.5mm x 1.5mm
TI	TPS5436	1.5W	90%	1.5mm x 1.5mm
TI	TPS5437	1.5W	90%	1.5mm x 1.5mm
TI	TPS5438	1.5W	90%	1.5mm x 1.5mm
TI	TPS5439	1.5W	90%	1.5mm x 1.5mm
TI	TPS5440	1.5W	90%	1.5mm x 1.5mm

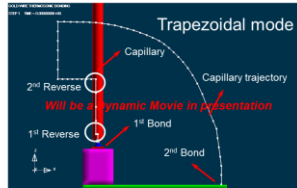


C: Multi-physics CAE analysis

Triangle mode is a standard loop with one reverse bend, used for short and high profile application

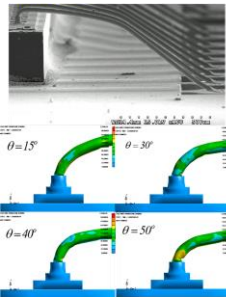


Trapezoidal mode is a loop with two reverse bend, used for low profile applications

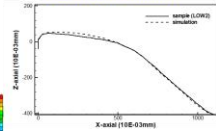


Published in "Finite Elements in Analysis and Design", Vol 40, No. 3, pp. 283-286, 2004

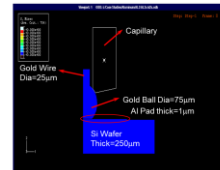
SEM Photo



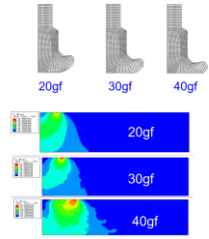
FEM Model Validation



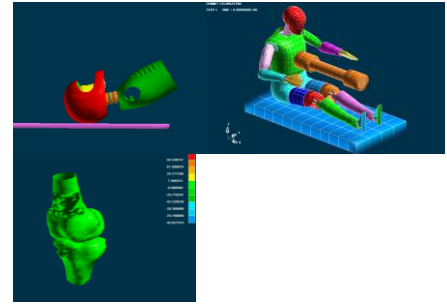
As bending angle increased, the loop height decrease. However, the loop strength also decreased.



1/2 Symmetry 2D FEM Model



Bonding Force on ELK Stress



Biomechanics and car safety dynamic analysis

Design and optimization of wire-looping process

Bonding stress on ELK