Multi-physics modelling for Flexible Hybrid Electronics

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Multi-physics modelling for Flexible Hybrid Electronics

- Stretching
- Bending
- Twisting

Electrical Simulation
Mechanical Simulation
Thermal Simulation

- Modeling operating conditions important
- Possible scenarios:
  - Mechanical loading changes electrical response due to geometrical changes
  - Mechanical loading changes electrical properties

- Questions to be answered:
  - Are such effects important?
  - How do you model the electrical response in such scenarios?
  - Are the commercially available tools adequate?
  - How complex are such simulations?
  - Can you develop models that are predictive and capture behavior?
Aerosol Jet Printed Microstrip Line

- 5 mil Kapton Polyimide with single-sided 18 µm Copper coating
- UTD silver nano-ink

**Modeling**

**Testing Structures**

- De-embedding
- Lines

**Electrical Response Changes with Bending (Modeling)**

- Insertion Loss for Tensile Bending Lines
- Return Loss for Compressive Bending Lines

**Measurement**

- Tensile
- Compressive

**Electrical Response Doesn’t Change with Bending (Measurement)**

- Are Modeling Tools Incorrect?
- No (In this Case)
- Difficulty in replicating measurement setup in the Tool is the problem!
• 5 mil Kapton Polyimide with 18 µm Copper ground plane
• Silver ink 10.5 µm

- With decreasing panel separation both the inductance and Quality Factor decrease (measurements).
- Modeling captures this effect partially!
Screen Printed Power Inductor (Multiple Cycles)

- Tensile Bending
- Four Cycles
- Flat – 15mm Panel Separation – Flat - ....
- Substantial change in Inductance & Q Factor
- Unable to capture the Memory effect in Modeling!
Tools have reasonable capability to share Mechanical and Electrical Geometric Models
  - Challenge
    - Unable to reproduce the exact mechanical loading conditions

Multi-physics Modeling
  - Challenges
    - Requires significant user expertise to set-up model
    - Numerical instability a problem sometimes
    - Does not account for any electrical property change due to mechanical loading (Ex: Resistance Change)
    - Does not account for any memory effects (Ex: Multiple cycle bending)
    - CPU & Memory Intensive

What needs to happen for FHE to succeed
  - Tools need to be well calibrated with measurements, gaps identified & solutions developed to fill gaps.
  - Predictive modeling required that is Super Fast and error free
    - Correlate Multi-physics model with Measurements
    - Rely on tools to generate data samples
    - Use Machine Learning to develop predictive model
      - Incorporate into Process Design Kits (PDK)