MEMS Test Structures for Residual Stress Measurements

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Outline

➢ Motivation
➢ Theory
➢ Results and Discussions
➢ Summary
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MEMS Test structures*

- Displacement Type: T, H shape structure
- Buckling Type: Beams, Cantilevers, Gückel Rings, Diamond structure
- Rotation Type: Pointers, Bent-beam, Lancet structures

Residual Stresses

### Theory

**Basic Layout of Lancet**

- **Anchor**
- **Tilted Beam**
- **Driving**
- **Junction**
- **Pointer**

**Compressive**  **Tensile**

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**Figure:** Displacement as a function of tilt angle $\alpha$.

- Displacement (μm) vs. Tilt angle $\alpha$ (Deg)
  - 8-10deg.

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**Schematic of modeling sequence**

- **Strain** → **Tilted Arm Model** → **Force acting on driving Bar** → **Junction Model** → **Displacement**

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A. Conceptual schematic of the asymmetric lancet

B. Conceptual schematic of the symmetric lancet

displacement $X = \frac{H}{h} \left\{ DL_B + (L + \Delta L) \times \sin \left[ \arccos \left( \frac{L + \Delta L}{L + R} \right) \right] - L \sin \alpha \right\}$

$\text{displacement} = H \sin \alpha = H \sin \left[ \arcsin \left( \frac{x + \left( \Delta L_B + (L + \Delta L) \times \sin \left[ \arccos \left( \frac{L + R}{L + \Delta L} \right) \right] - L \sin \alpha \right)}{h / \sin \beta} \right) - \beta \right]$
Results and Observations

Asymmetric pointer structure with single junction layout
Asymmetric pointer structure with double junction layout
Asymmetric Lancet pointer structure with single junction and electrical read out

Cont...
Symmetric Lancet pointer structure with double junction and electrical read out
SEM image of fabricated symmetric lancet
## Summary

<table>
<thead>
<tr>
<th>Type Structures</th>
<th>Displacement (µm)</th>
<th>Stress (MPa)</th>
<th>Stress Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asymmetric Pointer</td>
<td>0.3</td>
<td>239</td>
<td>Tensile</td>
</tr>
<tr>
<td>Symmetric Pointer</td>
<td>0.9</td>
<td>217</td>
<td>Tensile</td>
</tr>
<tr>
<td>Asymmetric Lancet Pointer</td>
<td>3.5</td>
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<tr>
<td>Symmetric Lancet Pointer</td>
<td>6.7</td>
<td>228</td>
<td>Tensile</td>
</tr>
</tbody>
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References

Thank You!