Compressive Beam for a Bistable MEMS Memory Element

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Why MEMs Memory?

MEMS memory based on buckled stress can potentially be competitive with semiconductor flash memory:

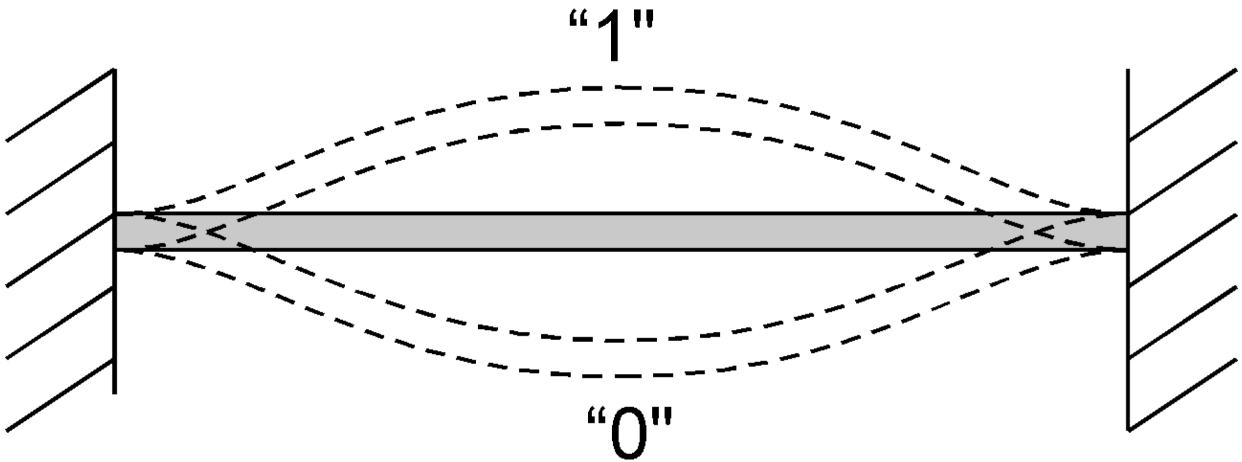
- *similar* size
- *smaller* write voltage
- *faster* write time
- *smaller* write energy.

Goal

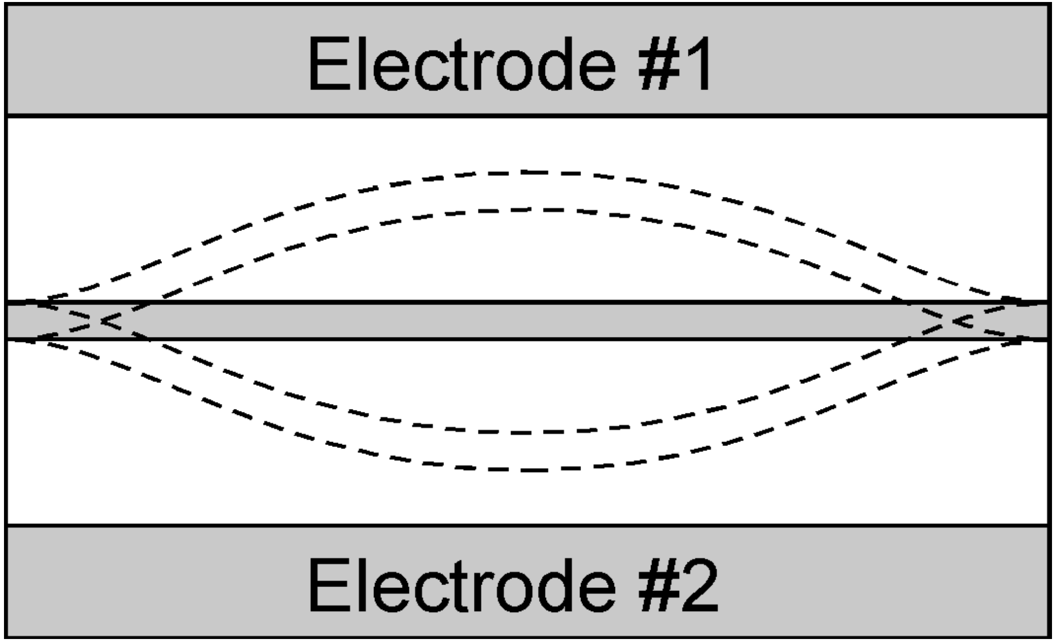
Develop a compressive, titanium tungsten beam that can be used for a bistable microelectromechanical systems (MEMS) memory device.

- Process compatible with other processing steps
- Can be easily freed from the substrate
- Beam must have large compressive stress with good mechanical integrity

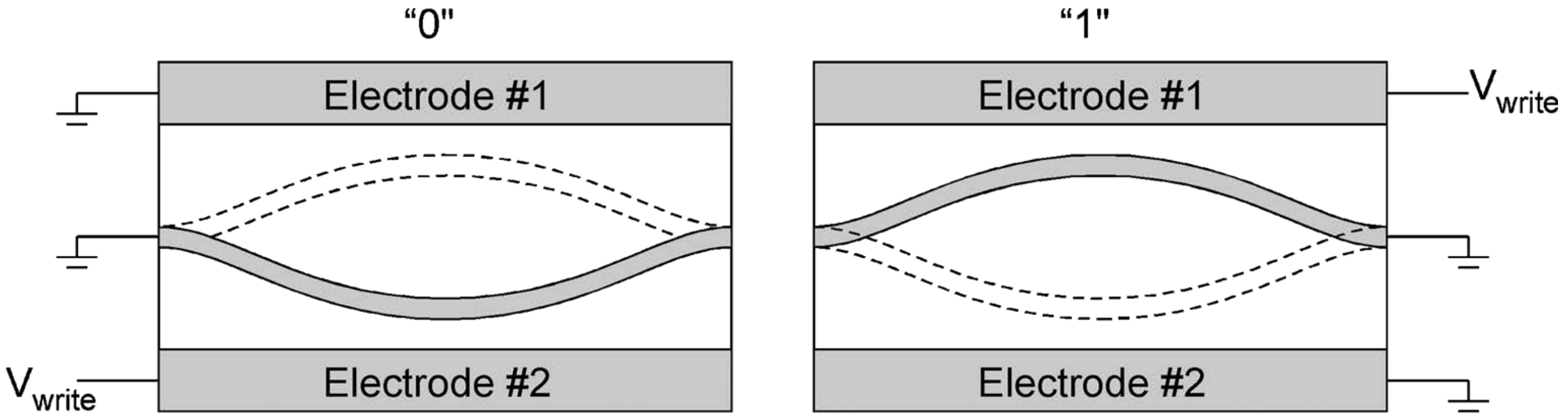
MEMs Memory: Design Concept



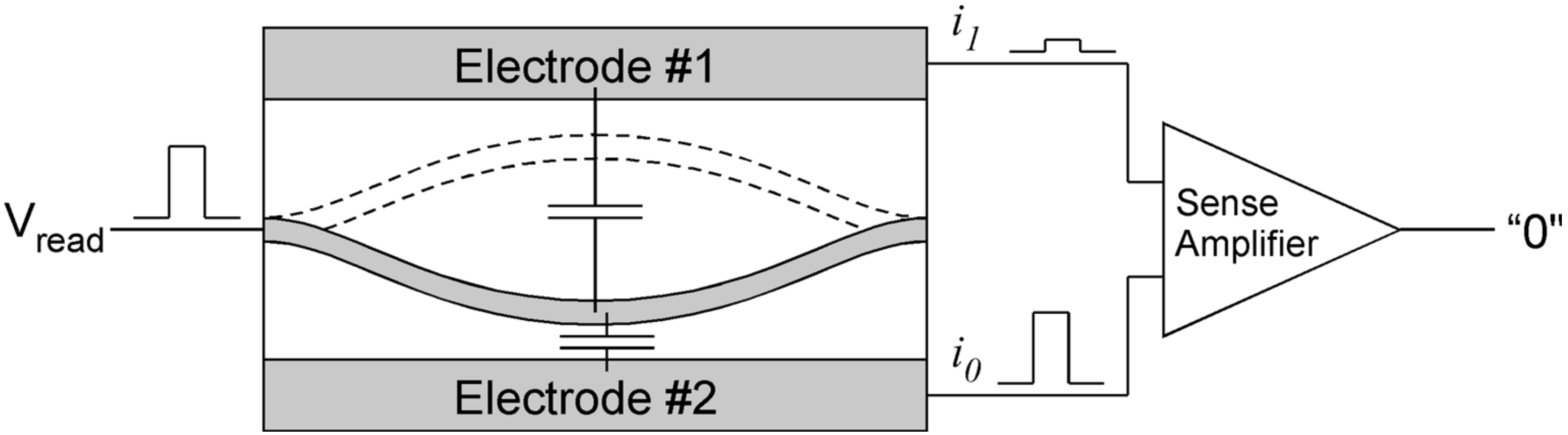
MEMs Memory: Read/Write Operation



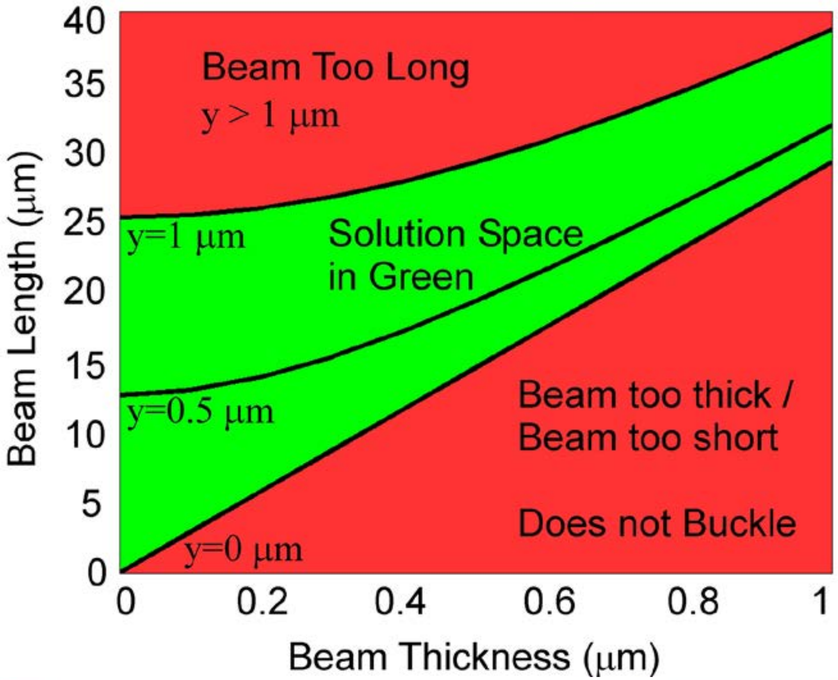
MEMs Memory: Write Operation



MEMs Memory: Read Operation



Center Displacement Calculations for TiW B



Center Displacement for Buckling Equation:

$$y_0 = \frac{2 * h}{\sqrt{3}} * \sqrt{\frac{\frac{\sigma}{E} * (1 - v)}{\frac{\pi^2}{3} * \frac{E'}{E} * \left(\frac{h}{l}\right)^2} - 1} * \sqrt{\frac{E'}{E}}$$

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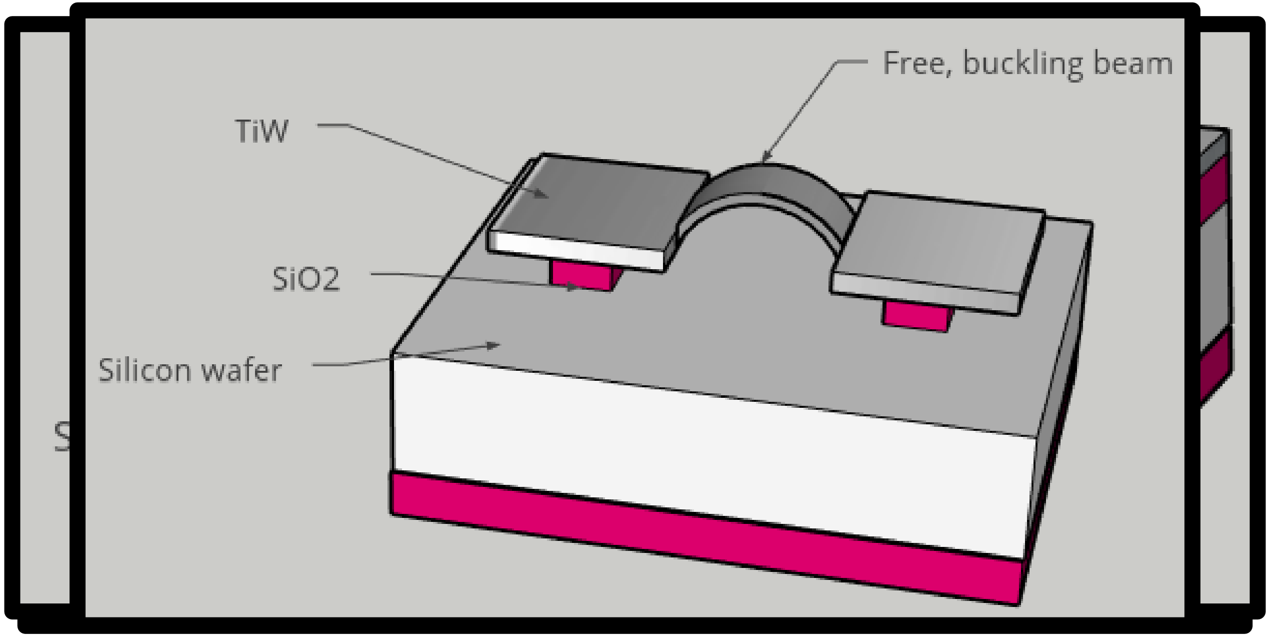
Device Fabrication: General Process



Device Fabrication: Process Development

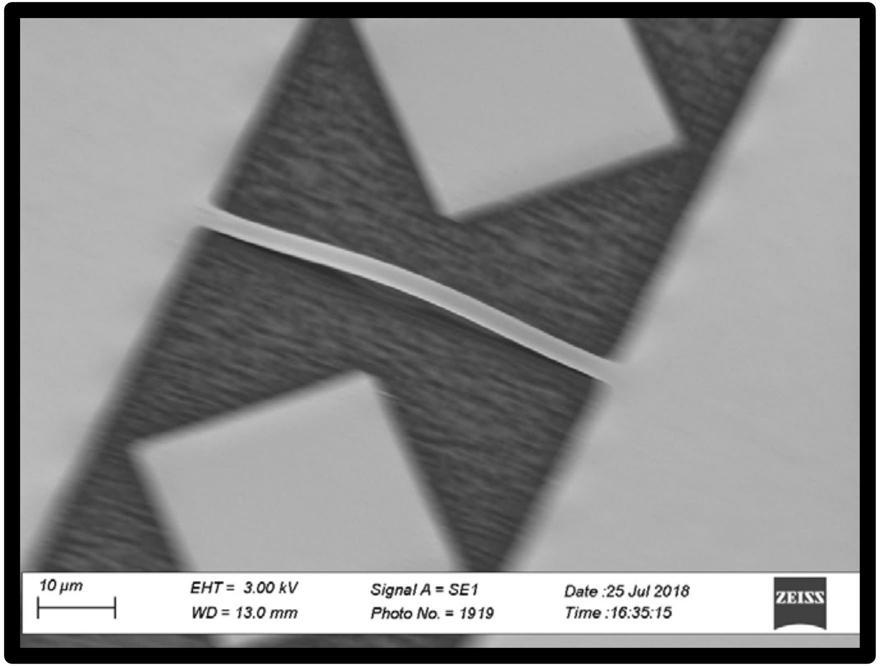
Conventional Sputtering

- Measured oxide thickness: 420nm
- Deposition conditions:
  - 300W DC for 20 minutes at 3 mTorr
- **Result:** 96.6 MPa (tensile)

Substrate -aided Sputtering

- Measured oxide thickness: 500nm
- Deposition conditions:
  - 20 minutes at 3 mTorr
  - 300W DC connected to TiW target
  - 20W RF connected to the substrate
- **Result:** -2050 MPa (compressive)

Testing and Results: 3μm x 50μm



Displacement		
Initial theoretical	Experimental (~5 μm of undercut)	Theoretical (~5 μm of undercut)
1.95 μm	3.5 μm	2.3 μm

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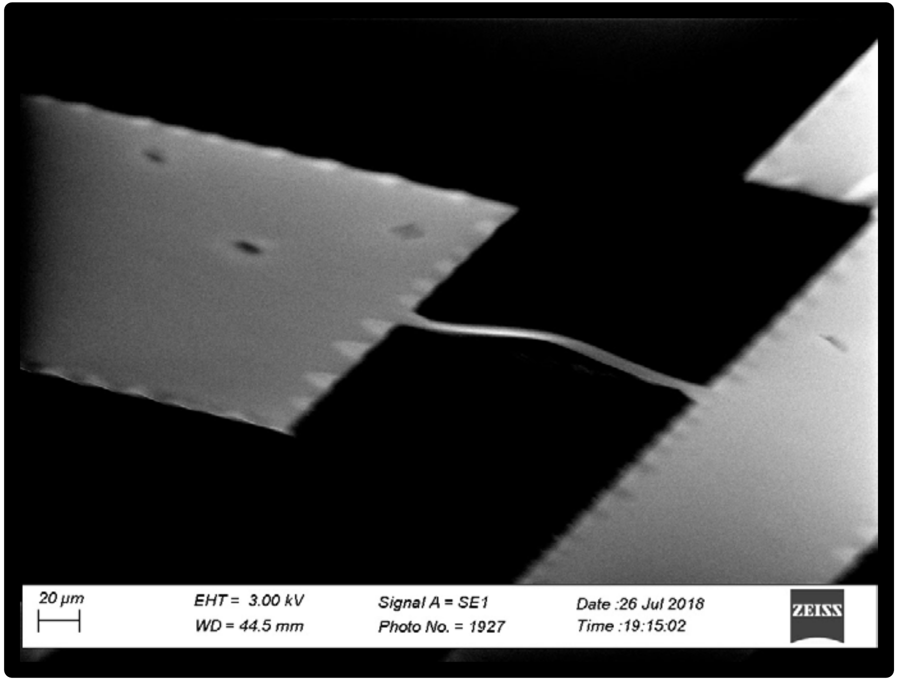
Testing and Results: 10μm x 100μm



Displacement		
Initial theoretical	Experimental (~6 μm of undercut)	Theoretical (~6 μm of undercut)
3.94 μm	6 μm	4.4 μm

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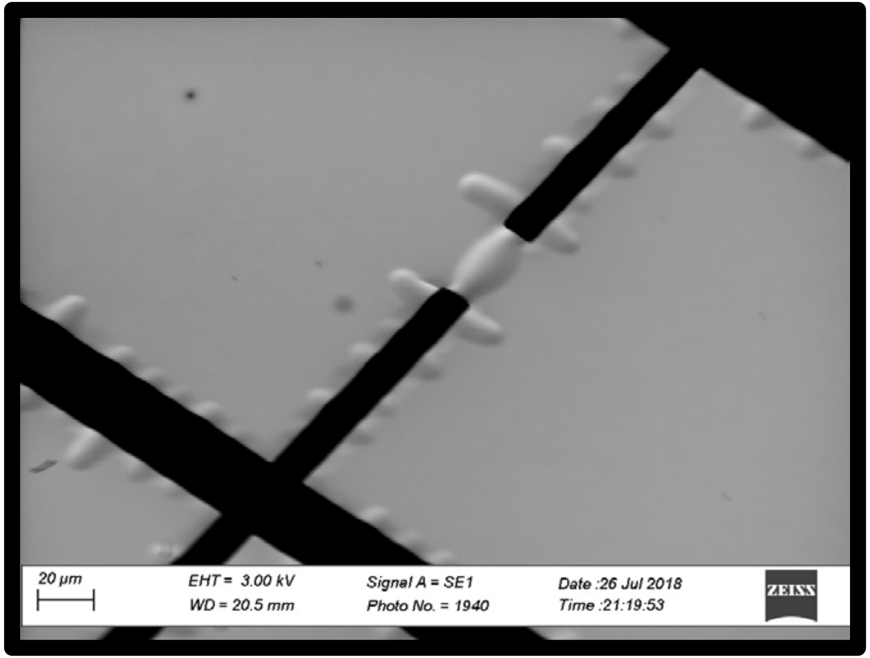
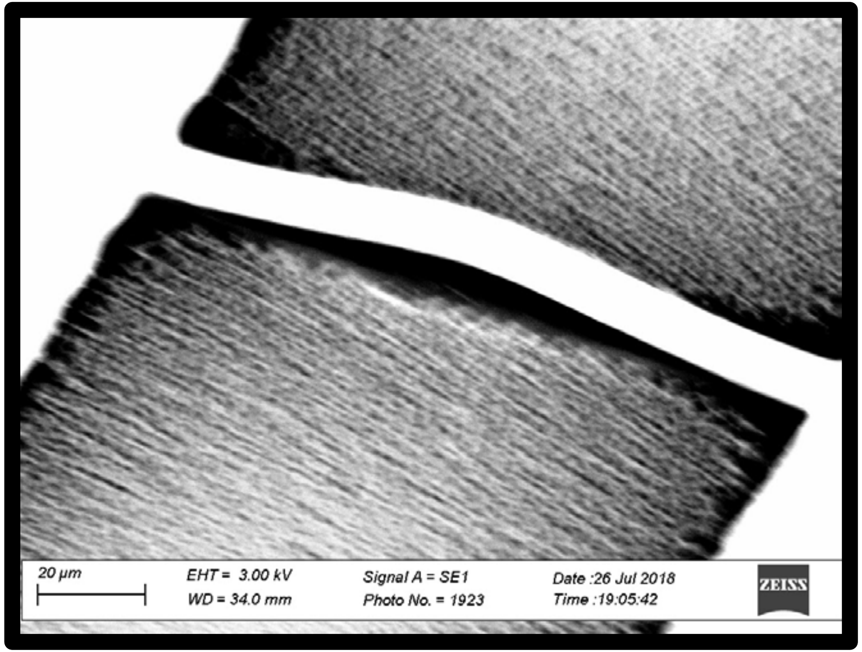
Testing and Results: 30μm x 10μm



Displacement		
Initial theoretical	Experimental (~9 μm of undercut)	Theoretical (~9 μm of undercut)
0.259 μm	0.9 μm	1 μm

Conclusions

- Successfully fabricated buckled beams
- Characterized the process flow
- Developed new sputtering technique to obtain compressive stress for future MEMs devices
- Achieved reasonable agreement between measured and calculated deflections



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