MicroAssembly Technologies

- MEMS SLMs
- MEMS-CMOS Integration
- High Force Actuators
- Low Temperature Bonding
- Nanolaminate Bonding

Wallace Tang, President  wallacet@microassembly.com
Product: MEMS SLM

- High Performance Tip-Tilt-Piston Actuators
- Reflector Transfer
- Linear Response
- DoD Contracts (AFOSR, DARPA, MDA)
Tool: MEMS Transfer Process
Low Temperature Bonding

- 300°C standard CMOS-compatible process, room temperature for Silicon substrates
- Thousands of reflectors at a time
- MEMS-CMOS Integration: Monolithic performance
- Hermetic/vacuum sealing

- Microbump integration: 100% yield, N=1024
- Pilot production
Relevant Technologies

• Electrostatic Comb Drive Piston Actuators*
  – Thick and Thin Single Crystalline Silicon (SOI) Mirrors
  – 5 Generations of Actuator Design & Fabrication (in collaboration with ARI)
  – Cryo Devices

• Nanolaminate Bonding

* patents pending
High Performance Piston Actuators

Relevant Part Under Development

- Comb drive piston actuators
- Piston stroke: 6 μm
- Frequency response: 27 kHz
- Size: 300 μm

- Conservative fabrication design rules (less than 10:1)
- Possible: Larger stroke, higher frequency response
- Already demonstrated much faster tip-tilt-piston devices*

* patents pending
Comb vs. Parallel Plate

• Parallel Plate
  – Foundry Process
  – “Proven”

• Comb Drive
  – High Energy Density: Stroke, Frequency Response
  – Fabrication Challenges: Alignment, Assembly, Large Arrays

• MicroAssembly Approach
  – Reduce etch steps
  – “Disintegration” and Assembly vs. Monolithic
Earlier Comb Process (ARI, 2001)
Nanolaminate Bonding

- Bond to dummy substrates
- Bond to actuators from BMC
- Low temperature thermocompression process
- Print-through concerns
- Edge effects
- Subcontract from LLNL
Nanolaminate Bonding: 1st Result

Surface Stats:
Ra: 491.80 nm
Rq: 611.67 nm
Rt: 6.17 μm

Measurement Info:
Magnification: 5.17
Measurement Mode: VSI
Sampling: 1.63 μm
Array Size: 736 x 480
Latest Bonding Result

Surface Stats:
Ra: 129.24 nm
Rq: 247.88 nm
Rt: 4.82 um

Measurement Info:
Magnification: 1.02
Measurement Mode: VSI
Sampling: 8.20 um
Array Size: 736 x 480

Title:
Latest Bonding Result

**Surface Statistics:**
- Ra: 5.95 nm
- Rq: 7.73 nm
- Rx: 43.50 nm
- Rt: 44.26 nm

**Set-up Parameters:**
- Size: 736 x 480
- Sampling: 820.31 nm

**Processed Options:**
- Terms Removed:
- Tilt
- Filtering:
  - None
Latest Bonded Sample
Next Steps

• MEMS SLM
  – Drive Electronics
  – MEMS Fabrication Iterations

• Collaboration with LLNL and Other System Designers

• Nanolaminate Bonding
  – Larger Substrates
  – Edge Effects
  – Actuator-Nanolaminate Bonding
Applications: Free Space Optics Telecom, Imaging, Targeting, Ophthalmic, Tweezers

Primary and Adaptive Optics and Communications

Transceiver Assembly, David Britz