



Recent Progress in Canadian Microbolometer and Micromirror Technologies



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4th Round Table on MNT for Space
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Introduction

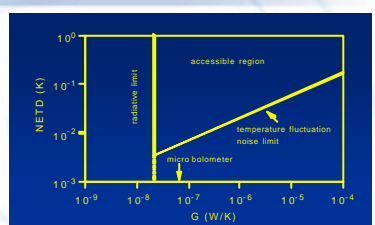



Initiative of CSA, DND, and INO in MEMS in 1995

- ▷ Microbolometer
- ▷ Micromirror






Need for MEMS




The graph plots NETD (K) on the y-axis (log scale from 10^{-3} to 10^0) against G (W/K) on the x-axis (log scale from 10^9 to 10^{-4}). A vertical line at $G \approx 10^7$ W/K is labeled 'micro bolometer'. A diagonal line represents the 'temperature fluctuation noise limit'. The region above the diagonal line and to the right of the micro bolometer line is labeled 'accessible region'. A vertical line at $G \approx 10^4$ W/K is labeled 'radiative limit'.

(Krusse, SPIE 2532-550)






Standard pixel design



Labels in the micrograph:

- Si_3N_4 bridge
- VO_x or YBaCuO film
- Si wafer w/ ROIC

Other pixel designs

Increased hinge length

39-um pixel with ref. pixel

25-um pixel with underneath hinges

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Pixel characteristics

Standard YBaCuO pixel
 $D^* \sim 3 \times 10^9 \text{ cm.Hz}^{1/2}/\text{W}$
 NETD < 50 mK @ $F/1$,
 300 K, LWIR

(Ngo Phong and Qiu, JVST **A18**, 635)

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Radiation testing

Proton: 10^{12} cm^{-2} @ 60 MeV

▷ No measurable change in resistance, output voltage, and noise

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MEMS packaging

Footprint: 50 x 50 mm²
 Vibration: MIL-STD-810-514
 Shock: MIL-STD-810-516
 Temp. cycle: MIL-STD-810-501


Footprint: 30 x 26 mm²
 No vacuum tube
 TEC embedded

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Camera packaging




Experimental camera




Amigo




modular 160x120




Linear arrays



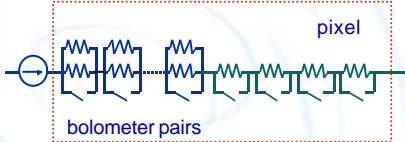
256 x 40



512 x 3
(supported by ESA)




Drift / offset compensation

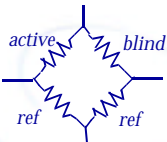


pixel


bolometer pairs



Drift / offset compensation

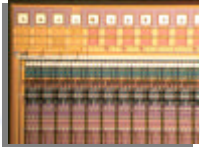


	active	blind	ref
radiation heating	x		
joule heating	x	x	
substrate heating	x	x	x




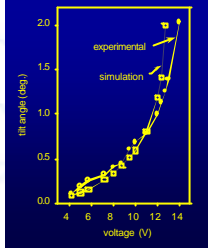
ROIC

- Sequential scanning or random access
- Pulsed or dc bias
- Switchable onchip filters



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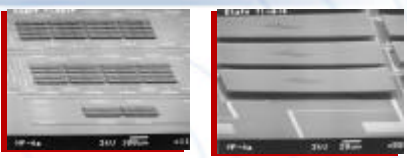
MEMS modeling

(Bühler et al., *J. Microelectromech. Syst.* **6**, 126)

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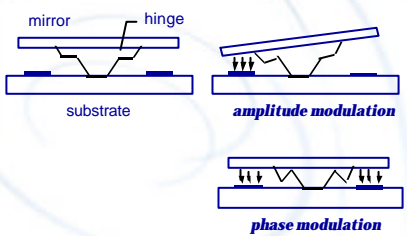
Flexure hinge mirrors



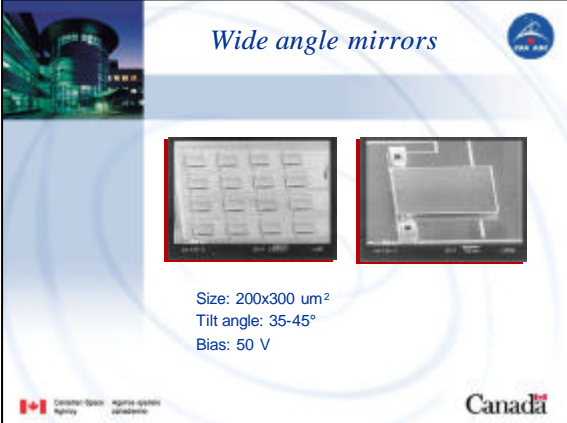
Size: 100x100 to 300x300 μm^2
 Tilt angle: 2-4°
 Bias: 15 V
 Switch time: 100 μs

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Operation modes



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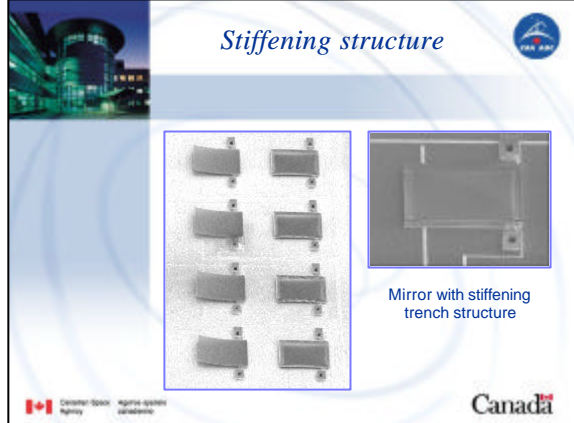


Wide angle mirrors

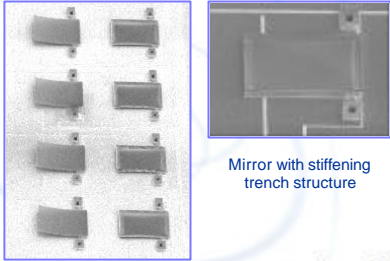


Size: $200 \times 300 \mu\text{m}^2$
Tilt angle: $35\text{-}45^\circ$
Bias: 50 V

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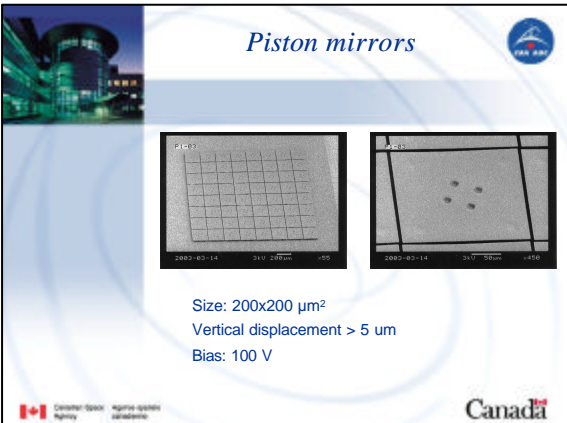


Stiffening structure

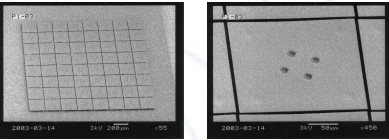


Mirror with stiffening trench structure

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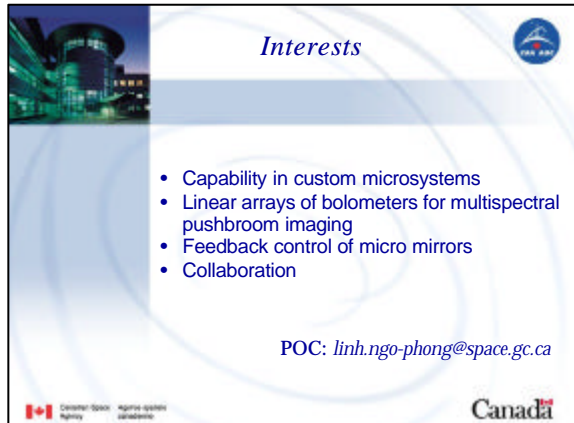


Piston mirrors



Size: $200 \times 200 \mu\text{m}^2$
Vertical displacement $> 5 \mu\text{m}$
Bias: 100 V

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Interests

- Capability in custom microsystems
- Linear arrays of bolometers for multispectral pushbroom imaging
- Feedback control of micro mirrors
- Collaboration

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