



# **MEMS Based Calorimetric Spectroscopy for Chemical Detection (Environment Monitoring)**

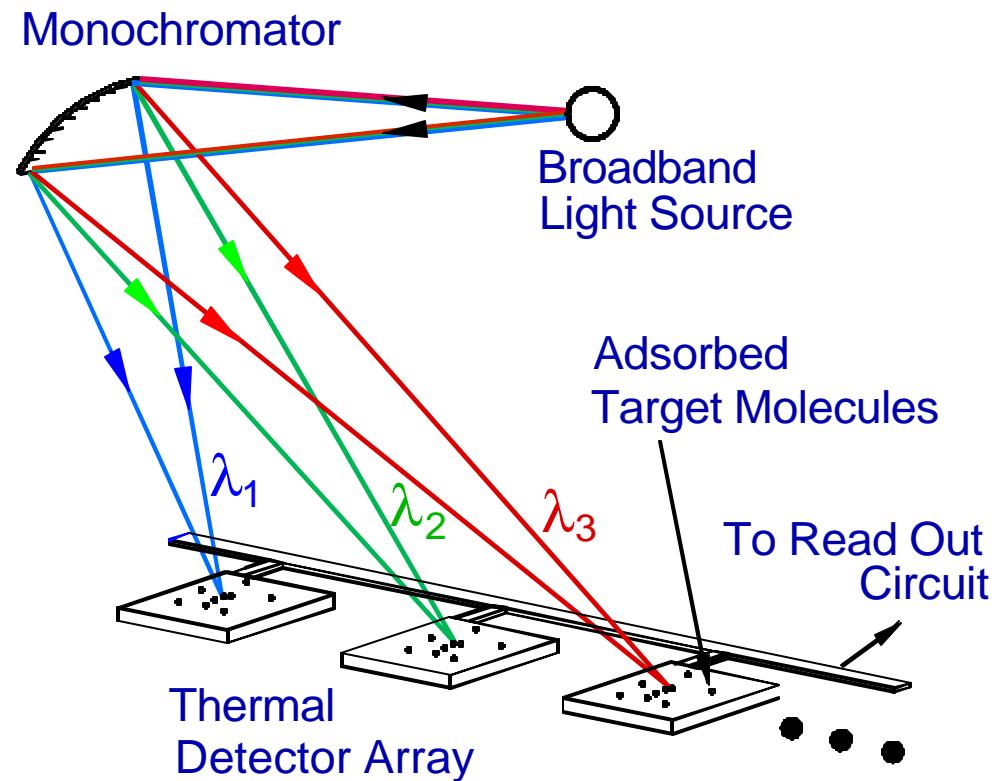
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**Oak Ridge National Laboratory**

# CalSpec Introduction

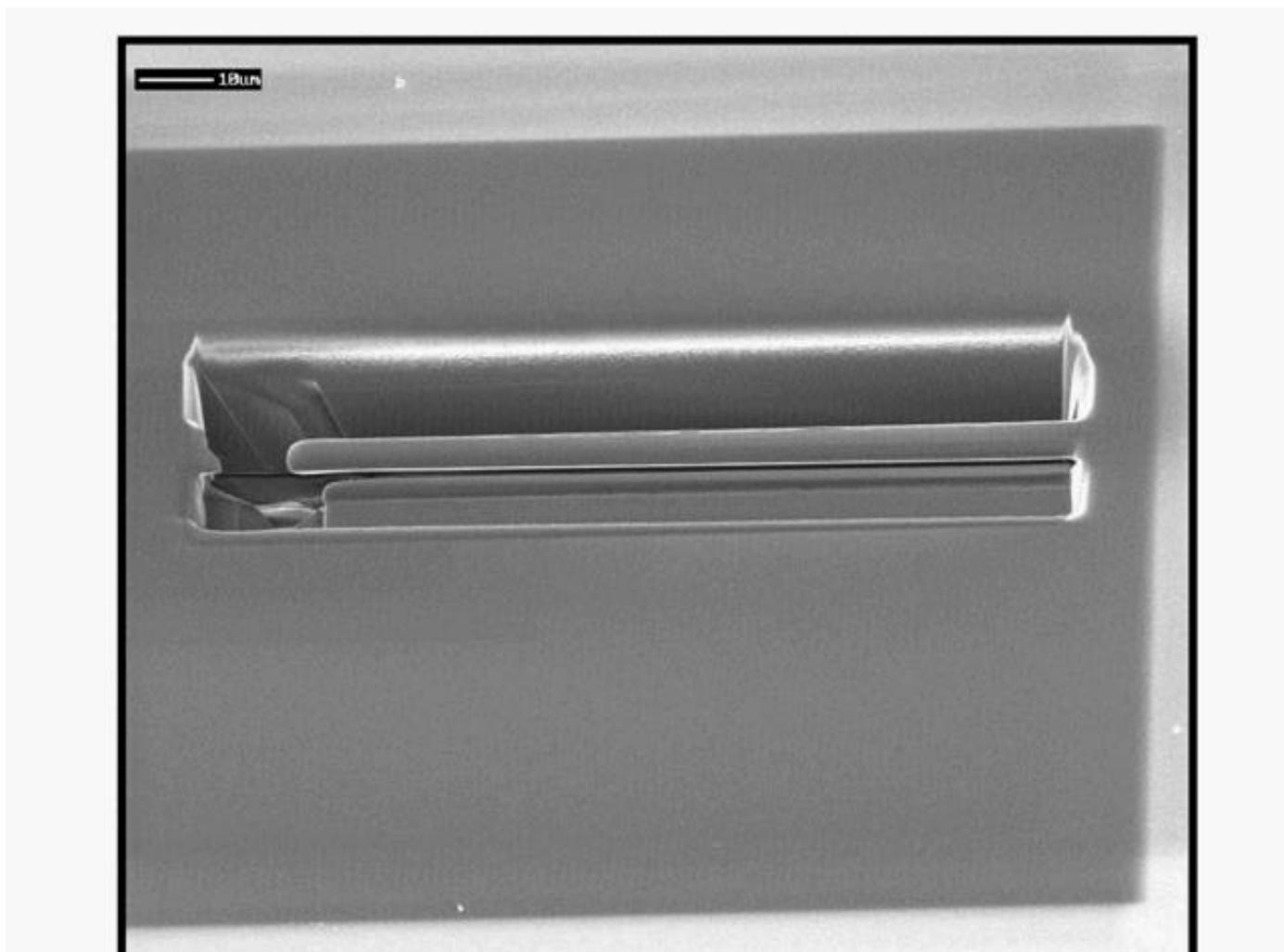
- Temperature based spectroscopy that relies on measurement of minute temperature differences, as a function of input photon wavelength.
- CalSpec used to detect trace quantities of various chemicals.
- Scalable chemical detection technology: From laboratory bench-top to hand-held box to coin-sized CalSpec on-a-chip.

# Calorimetric Spectroscopy Concept

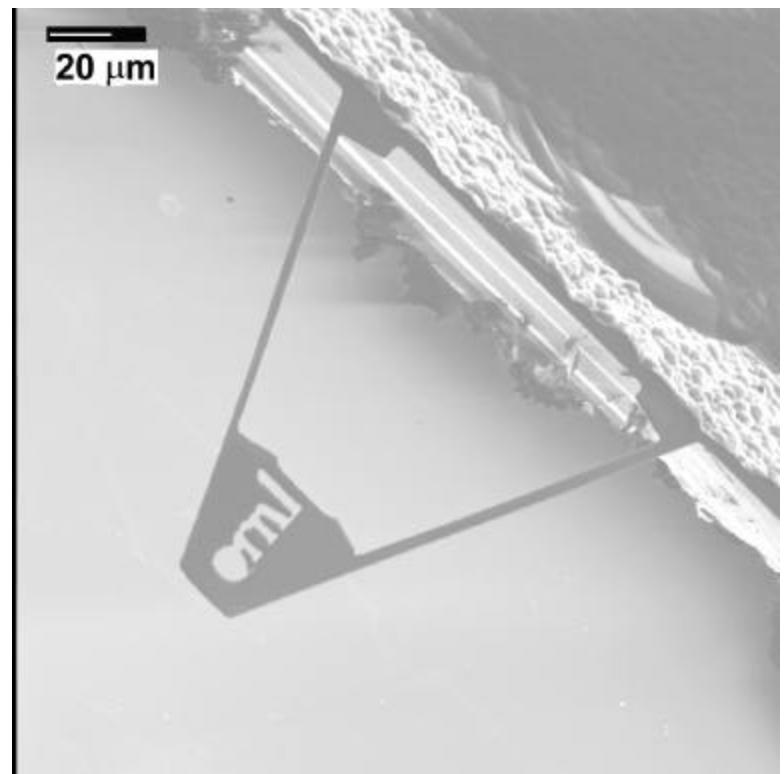
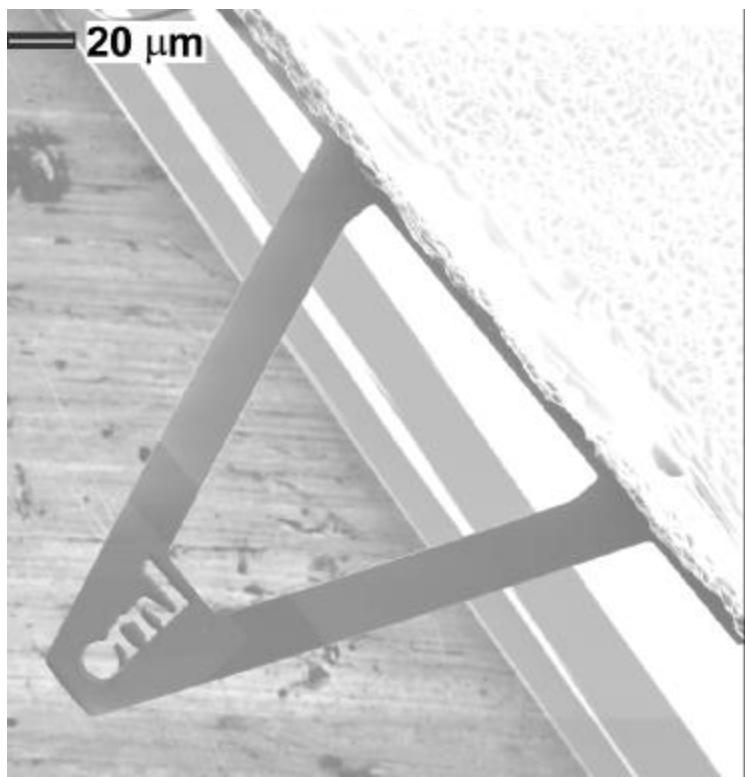
- Target molecules adsorbed on thermal detector surfaces.
- Detector surfaces illuminated with discrete wavelengths
- Photons absorbed and excite target molecules on selected detector elements
- Preferential detector element heating produces unique photothermal spectrum.



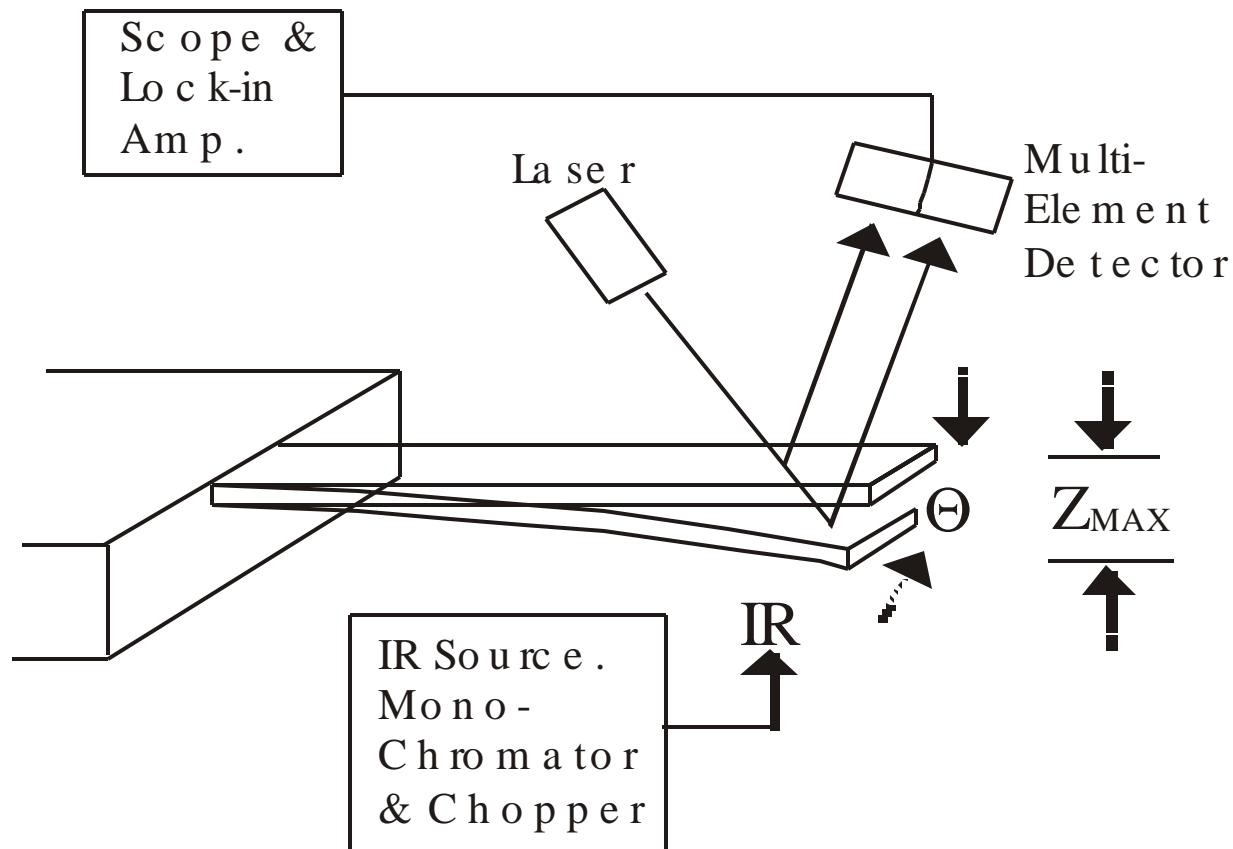
# Si Micro-Mechanical Thermal Detector



# Thermal Detector Optimization



# Experimental Setup



# Device Deflection Response

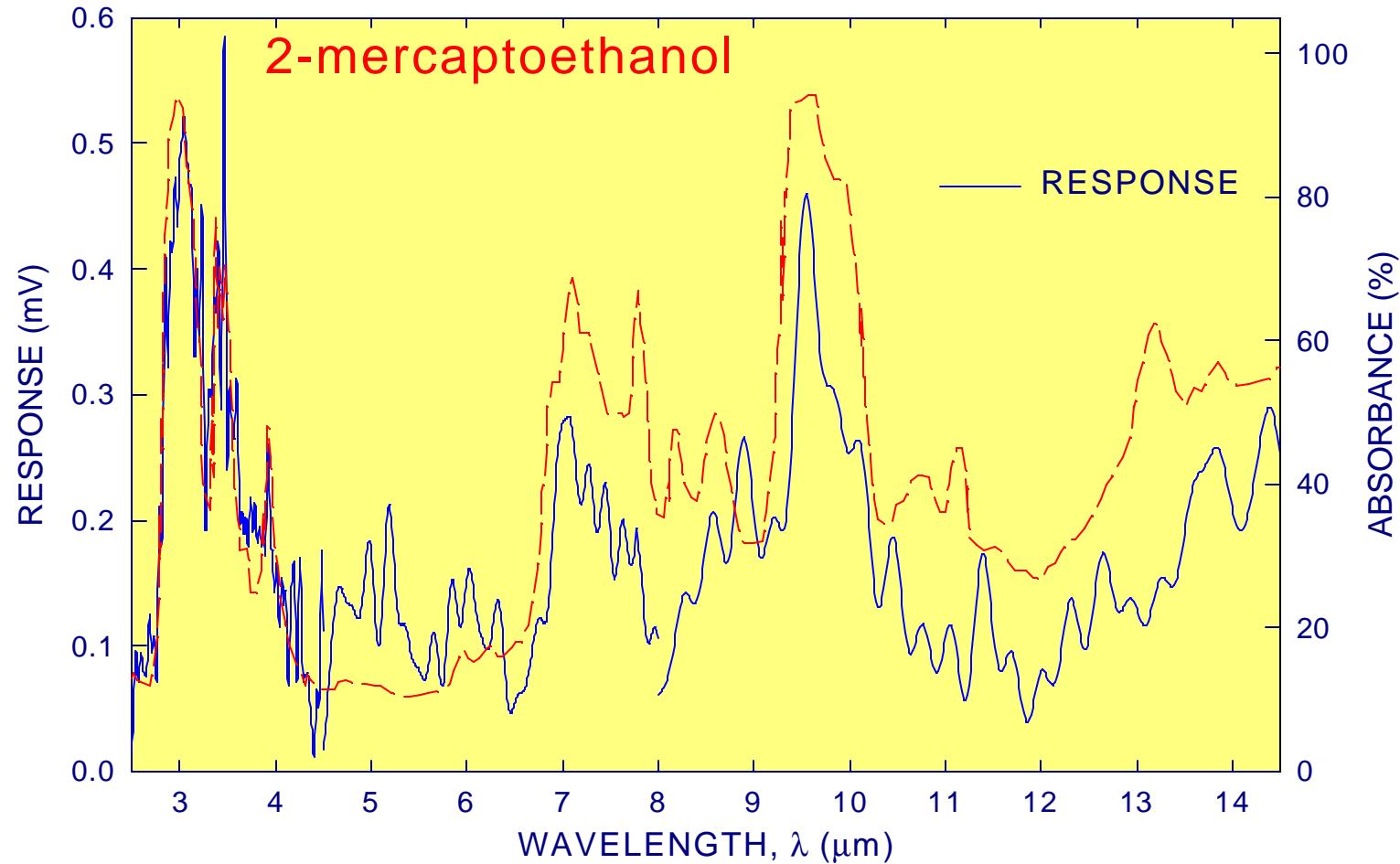
$$1_{\max} = \frac{6 \frac{(t_1 \cdot t_2) l}{t_2^2}}{\frac{4 \frac{t_1}{t_2} \frac{t_1^2}{t_2^2} \frac{E_1 t_1^3}{E_2 t_2^3}}{6 \frac{t_1}{t_2} \frac{t_1^2}{t_2^2} \frac{E_1 t_1^3}{E_2 t_2^3}}} \quad (T \& T_o)$$

$$Z_{\max} = \frac{3 \frac{(t_1 \cdot t_2) l^2}{t_2^2}}{\frac{4 \frac{t_1}{t_2} \frac{t_1^2}{t_2^2} \frac{E_1 t_1^3}{E_2 t_2^3}}{6 \frac{t_1}{t_2} \frac{t_1^2}{t_2^2} \frac{E_1 t_1^3}{E_2 t_2^3}}} \quad (T \& T_o)$$

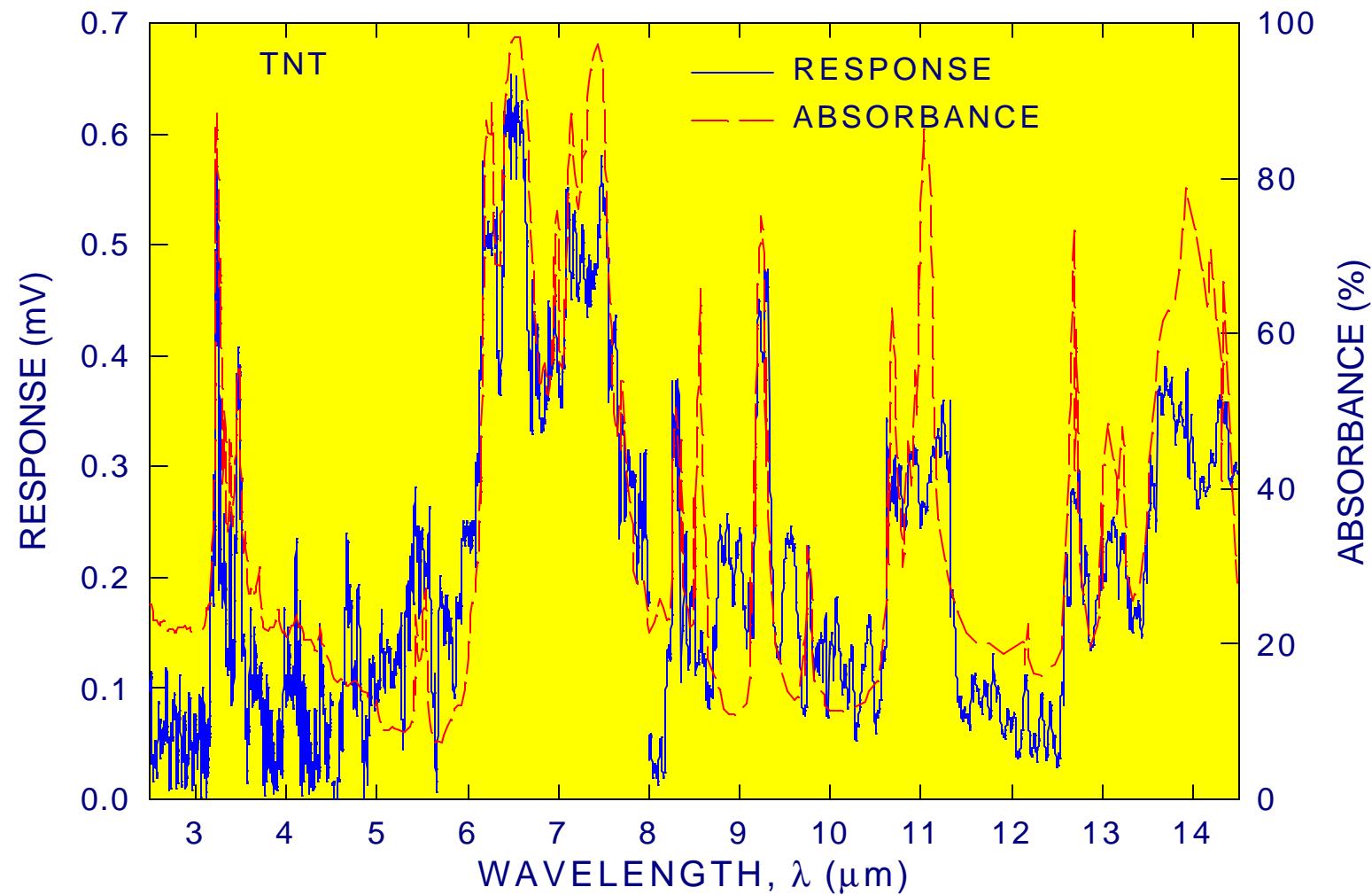
# 2-mercaptopropanoic acid

ornl

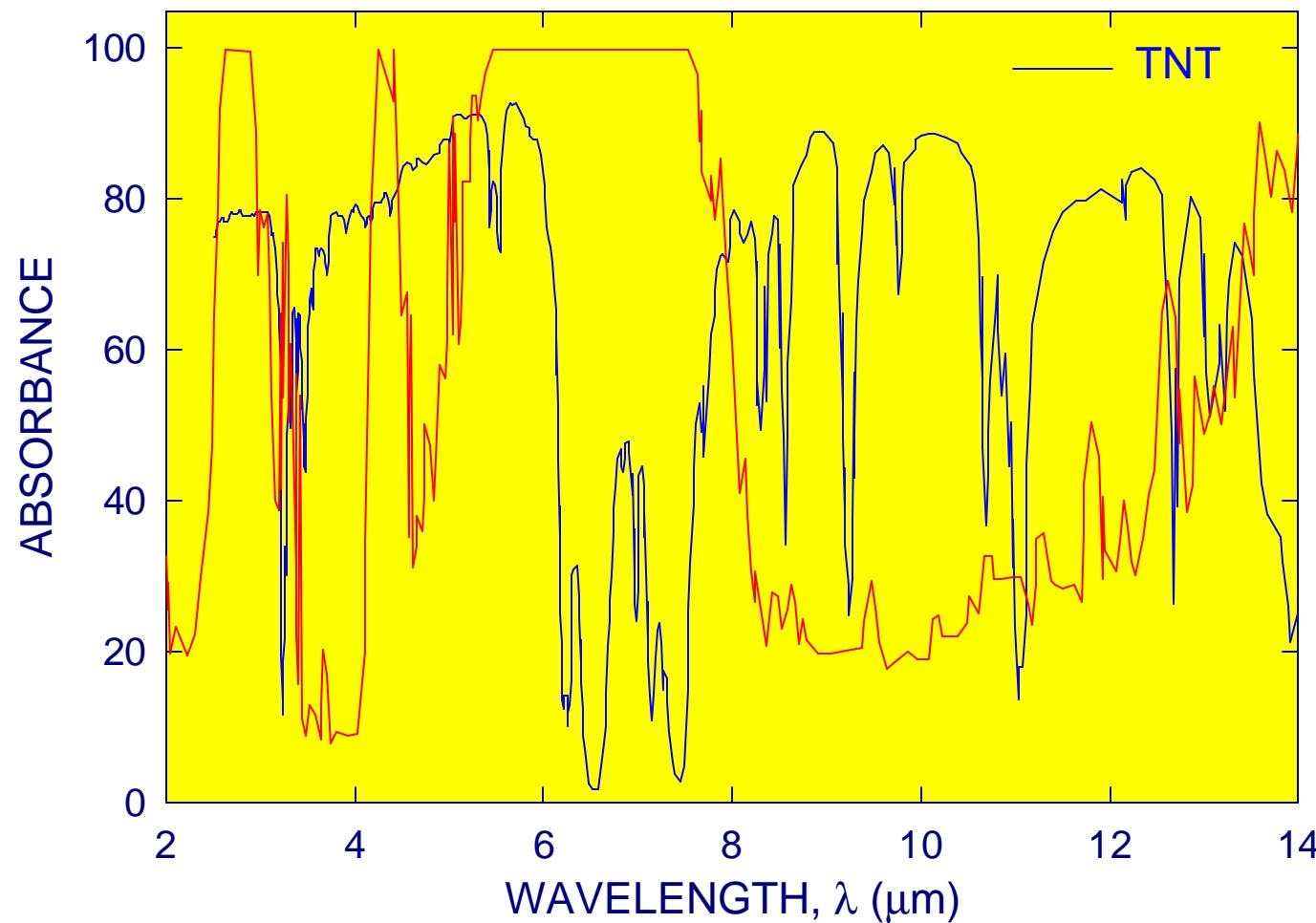
## Photothermal Signature



# TNT Photothermal Signature

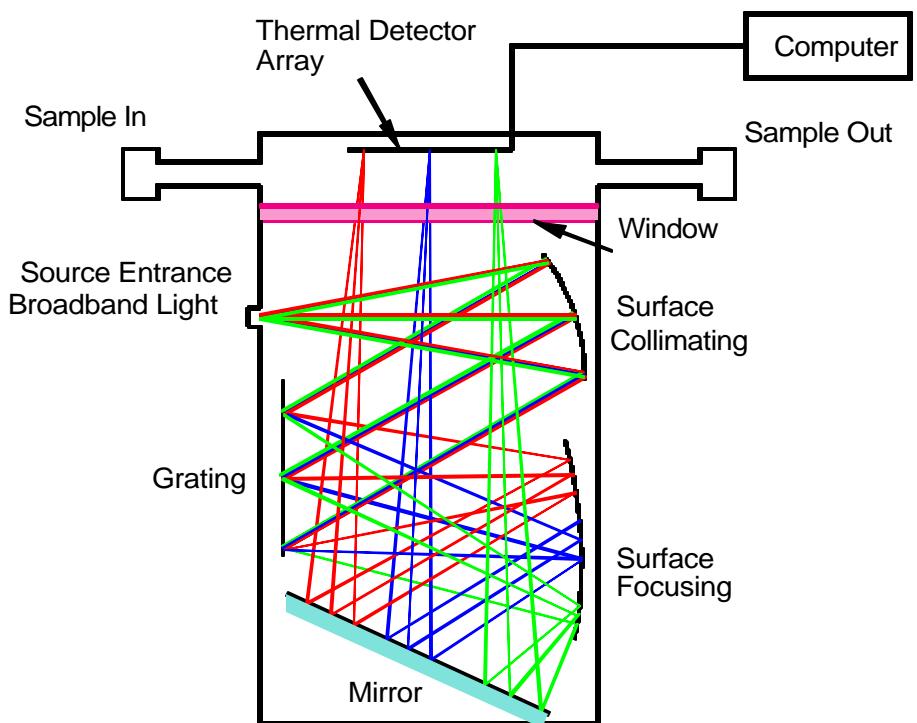


# Atmospheric Spectral Masking

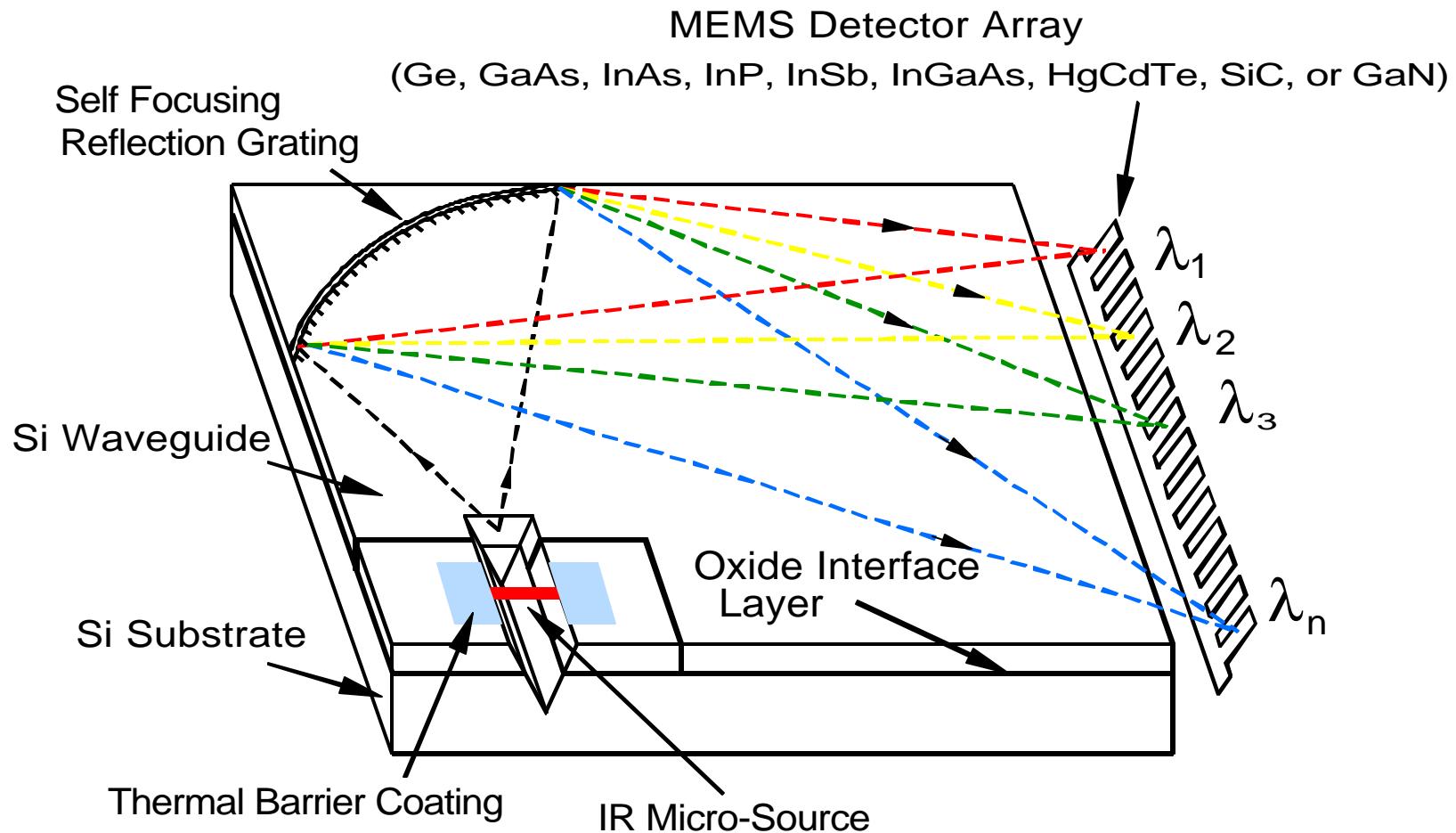


# CalSpec in-a-Box

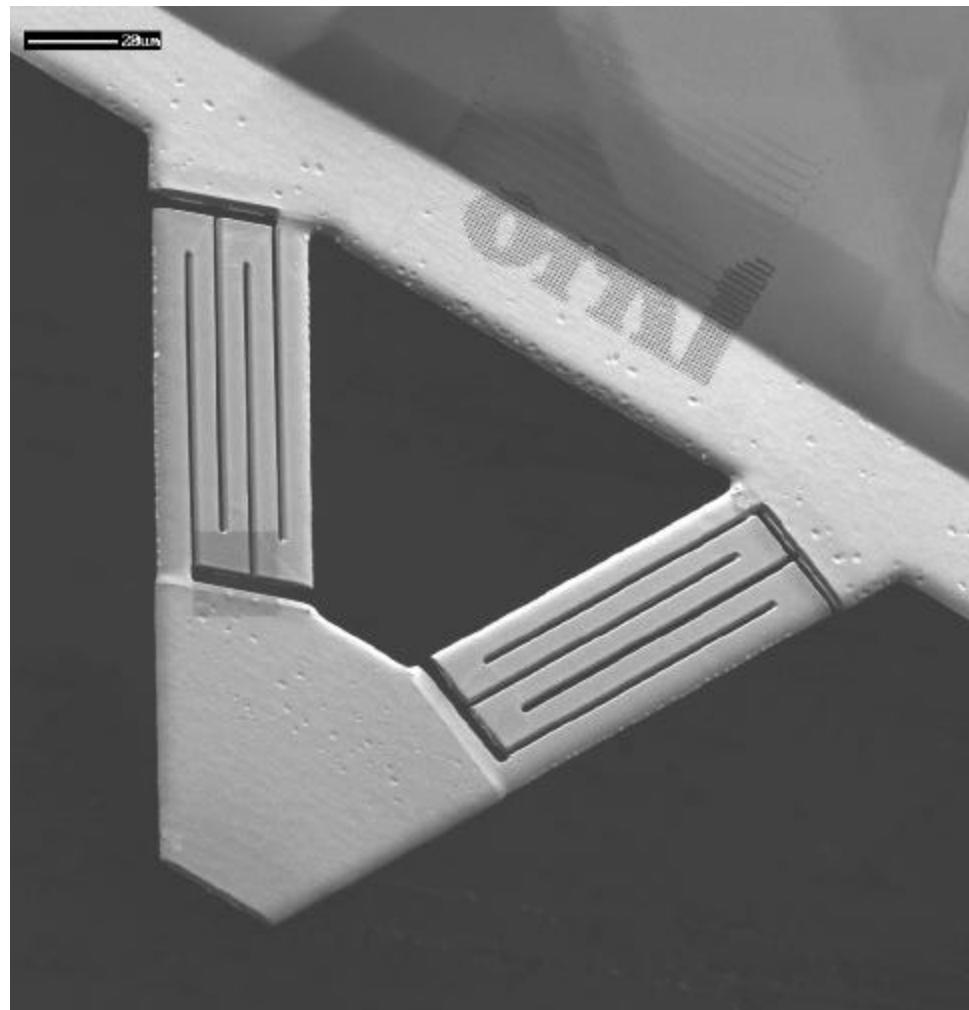
1998 R&D 100 Winning



# Coin-Sized CalSpec

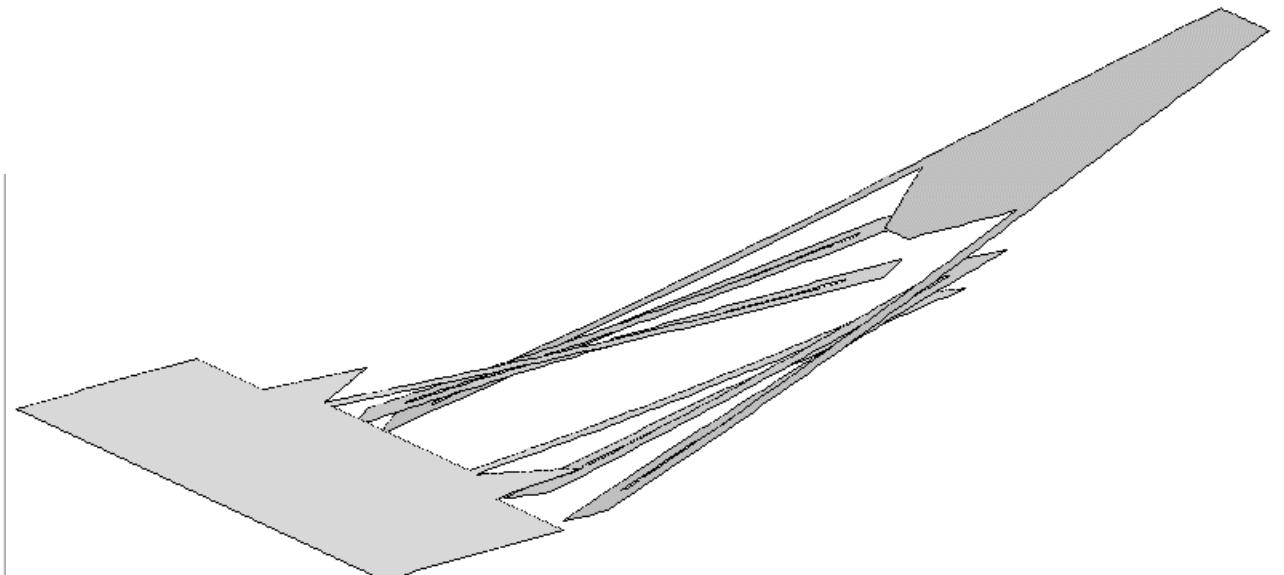
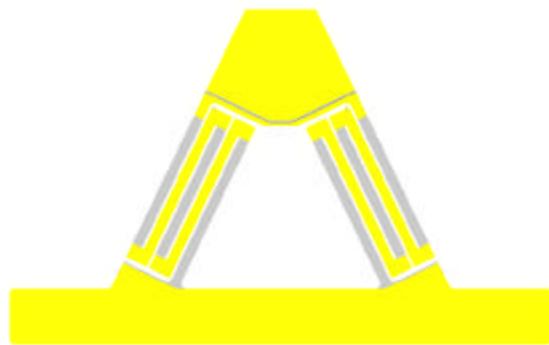


# Novel Ultra-Sensitive Thermal Detector Configuration

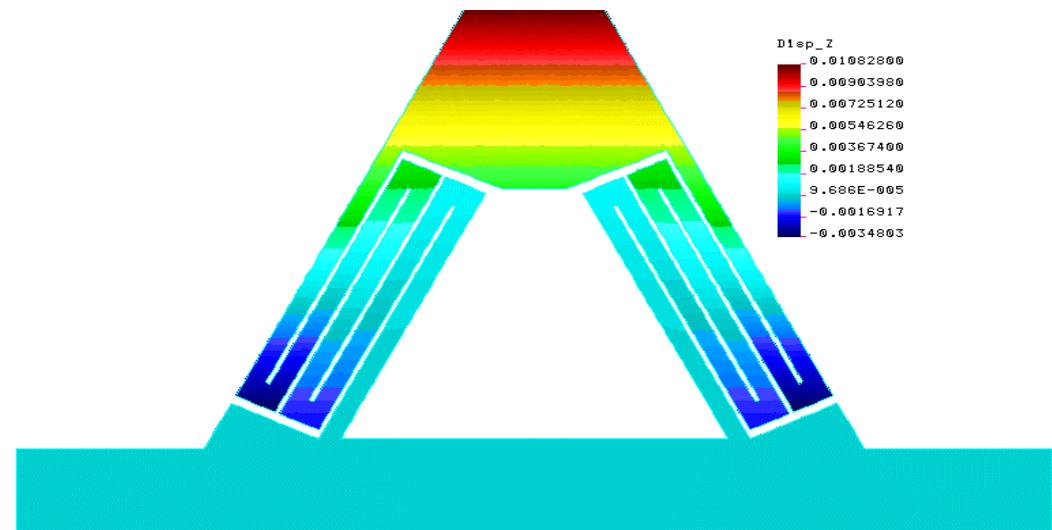
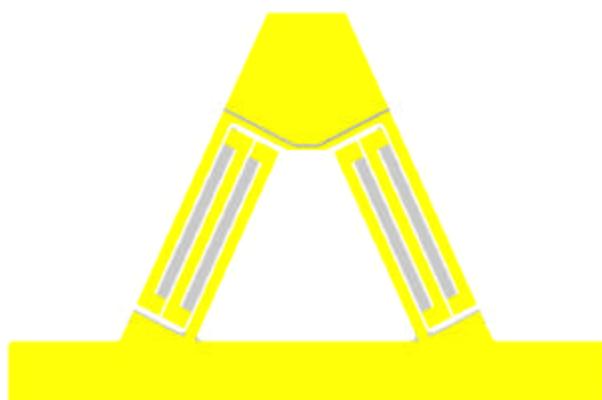


# Deflection Response

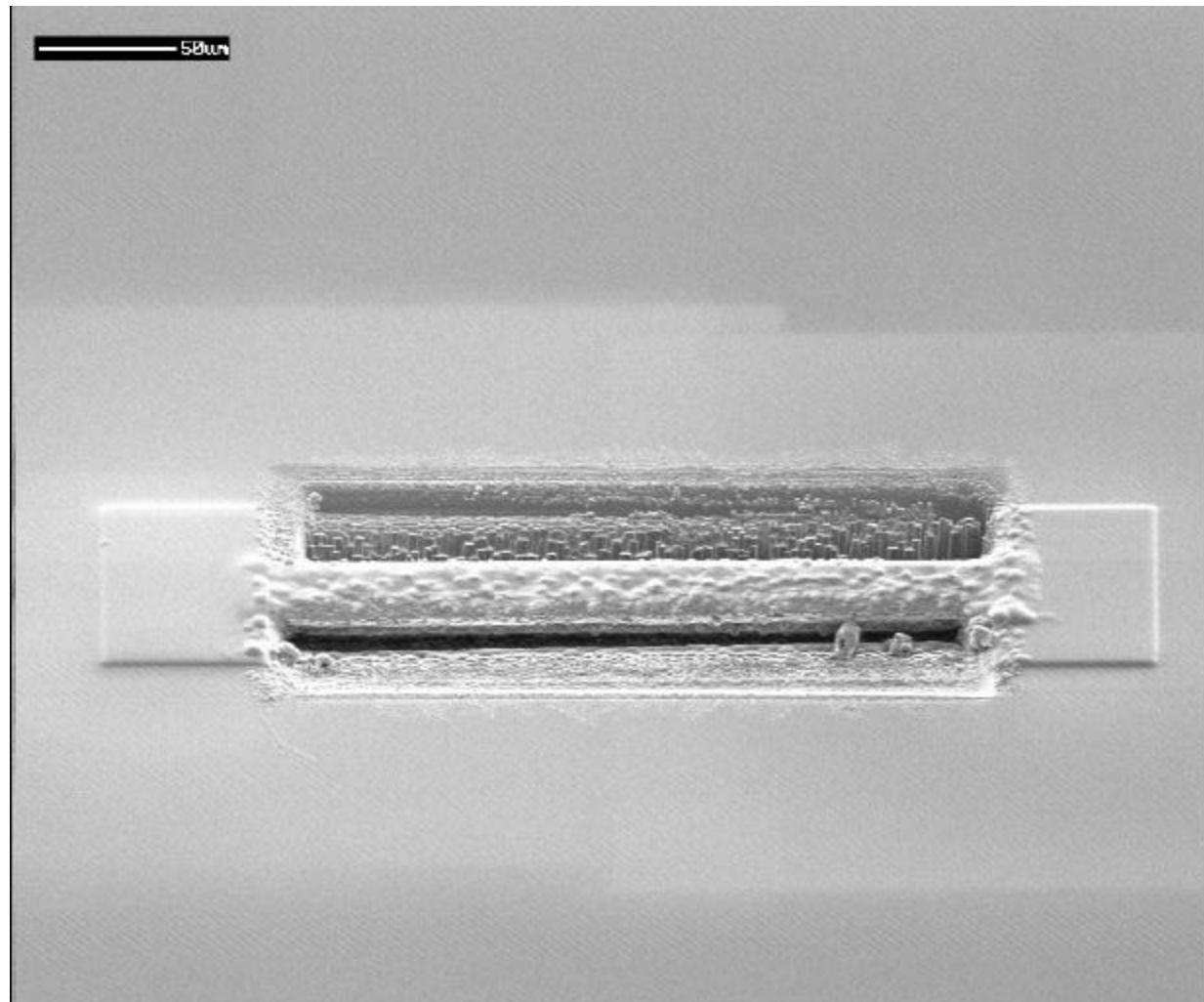
**Bottom View**



**Top View**



# Integrated IR Thermal Source



# Summary

**High sensitivity due to ultra-sensitive thermal detectors**

**High selectivity due to detailed spectroscopic interrogation**

**Technology ultimately amenable to coin-sized implementation**

**Extremely powerful and novel general vapor phase environment monitoring technology**