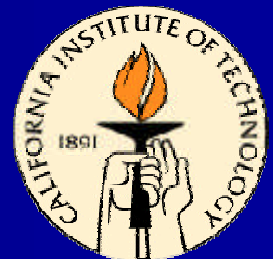


# Loss characterization in micro-cavities using the thermal bistability effect

**H. Rokhsari, S. M. Spillane, and  
K. J. Vahala**



# Loss Mechanisms

- Absorption

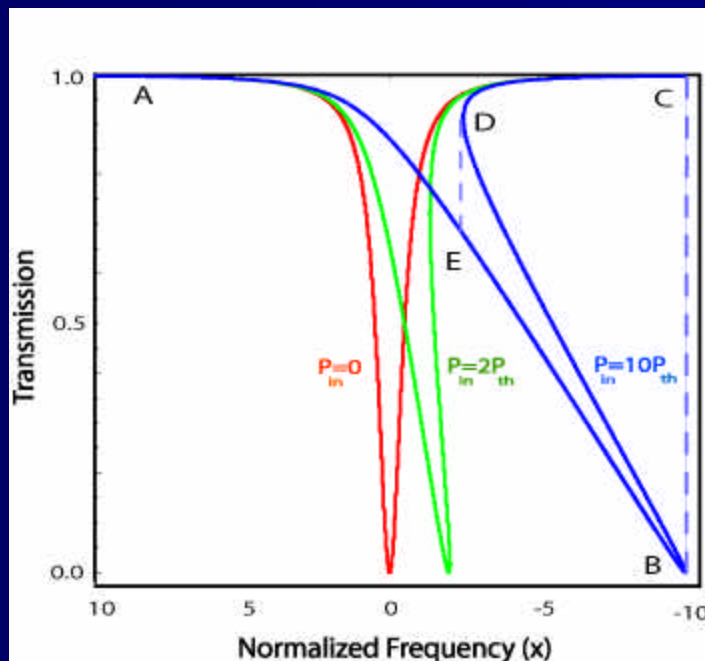
- bulk
- surface contaminants

- Scattering

- bulk scattering centers
- surface roughness

- Whispering Gallery

# Thermal Bistability Effect



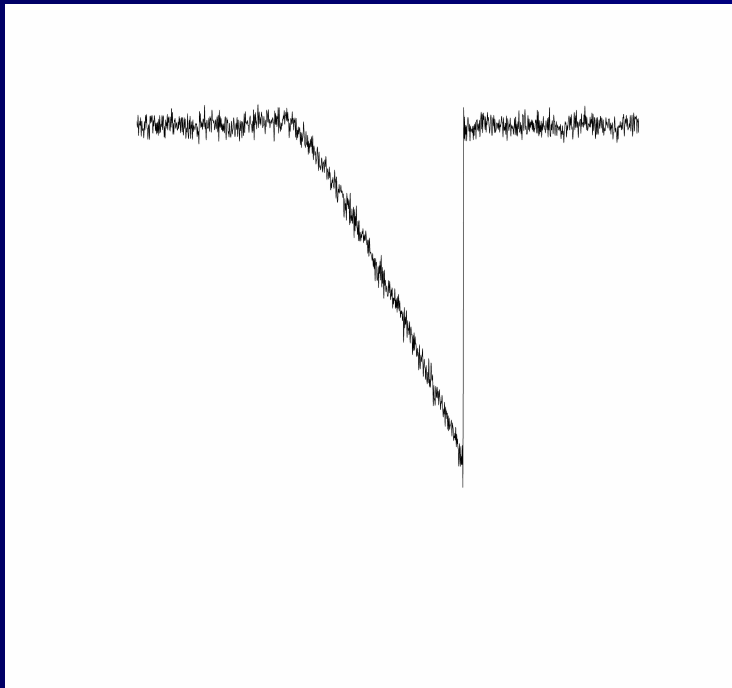
$$x = (\omega - \omega_0) / (\omega \omega_0)$$

$$(\omega - \omega_0) = -\omega_0 \frac{dn}{dT} \omega T$$

$$1 - T = \frac{C}{1 + 4 \left[ x + \frac{P_{in}}{P_{th}} (1 - T) \right]^2}$$

$$(\omega - \omega_0) / \omega \omega_0 = -\frac{P_{in}}{P_{th}}$$

# Thermal Bistability Effect



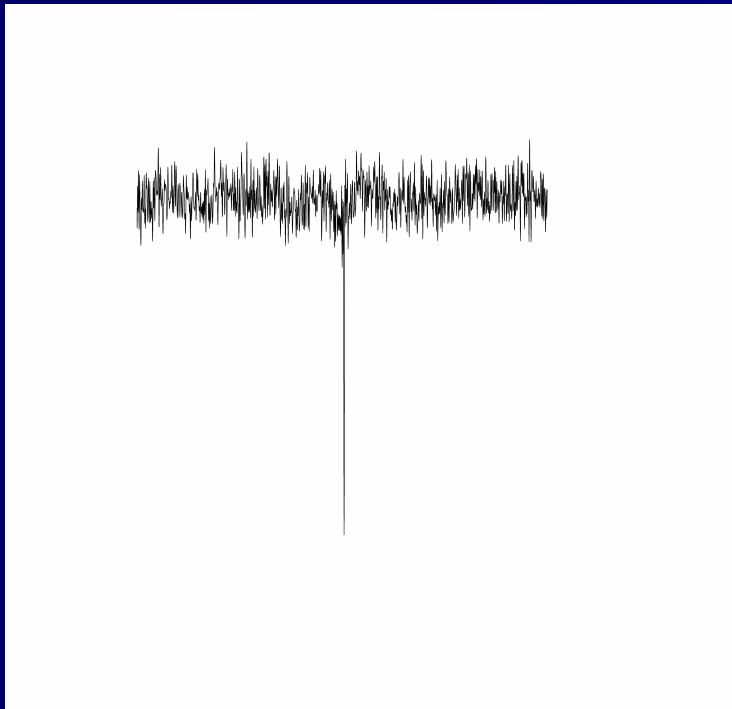
$$x = (T - T_0) / (T - T_c)$$

$$(T - T_0) = -T_0 \frac{dn}{dT} T$$

$$1 - T = \frac{C}{1 + 4 \left[ x + \frac{P_{in}}{P_{th}} (1 - T) \right]^2}$$

$$(T - T_0) / T_0 = - \frac{P_{in}}{P_{th}}$$

# Thermal Bistability Effect



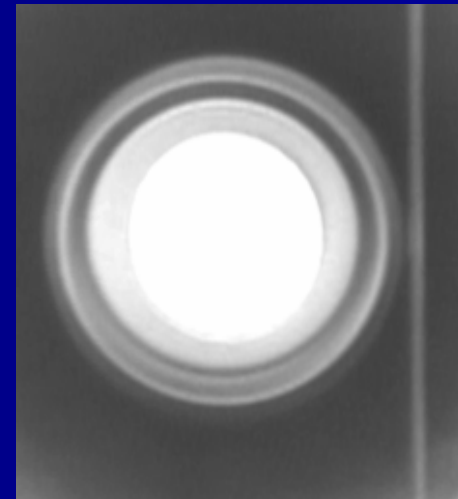
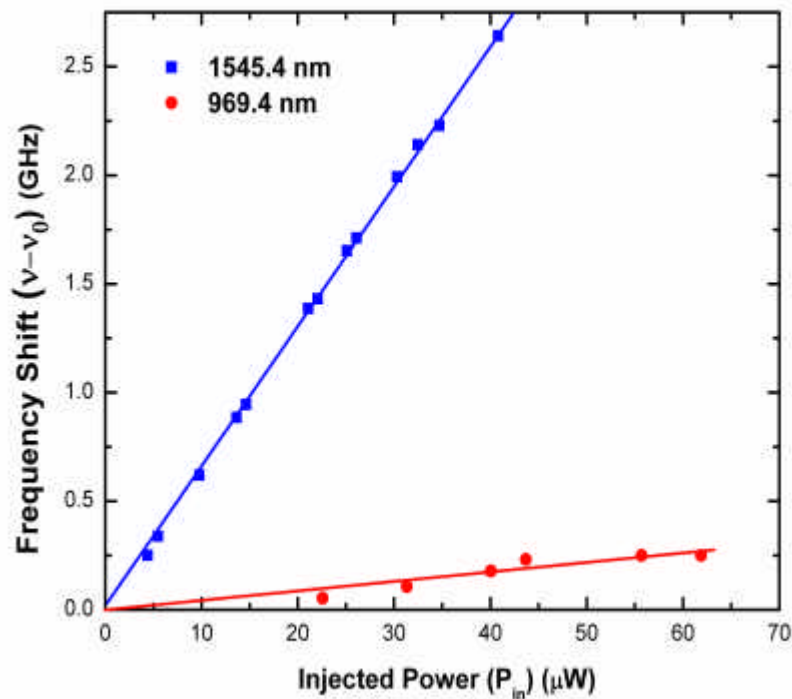
$$x = (T - T_0) / (T - T_c)$$

$$(T - T_0) = -T_0 \frac{dn}{dT} T$$

$$1 - T = \frac{C}{1 + 4 \left[ x + \frac{P_{in}}{P_{th}} (1 - T) \right]^2}$$

$$(T - T_0) / T_0 = - \frac{P_{in}}{P_{th}}$$

# Thermal Bistability Threshold power

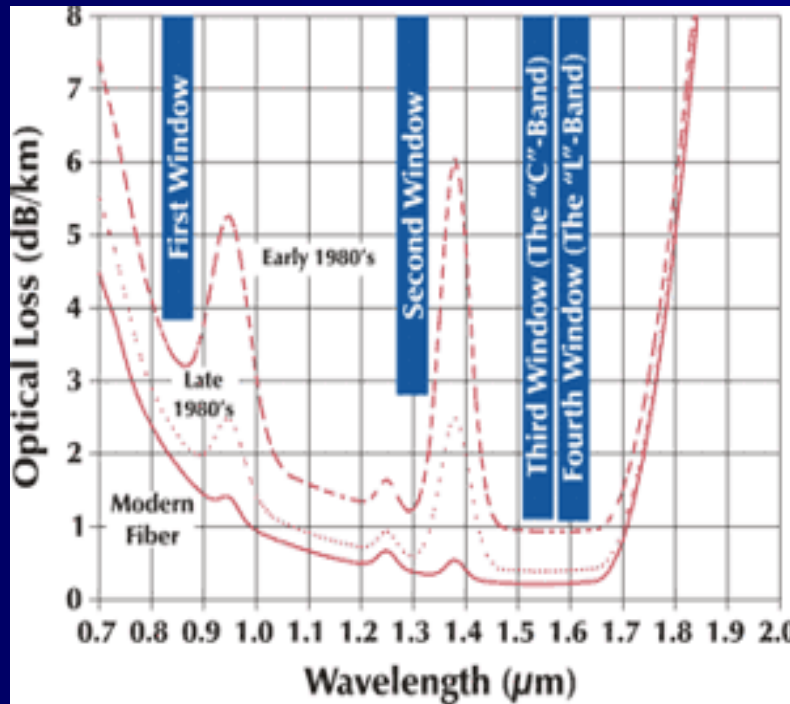


$$P_{th} \propto \frac{1}{Qa}$$

$$a = \frac{\textit{absorption}}{\textit{absorption} + \textit{scattering}}$$

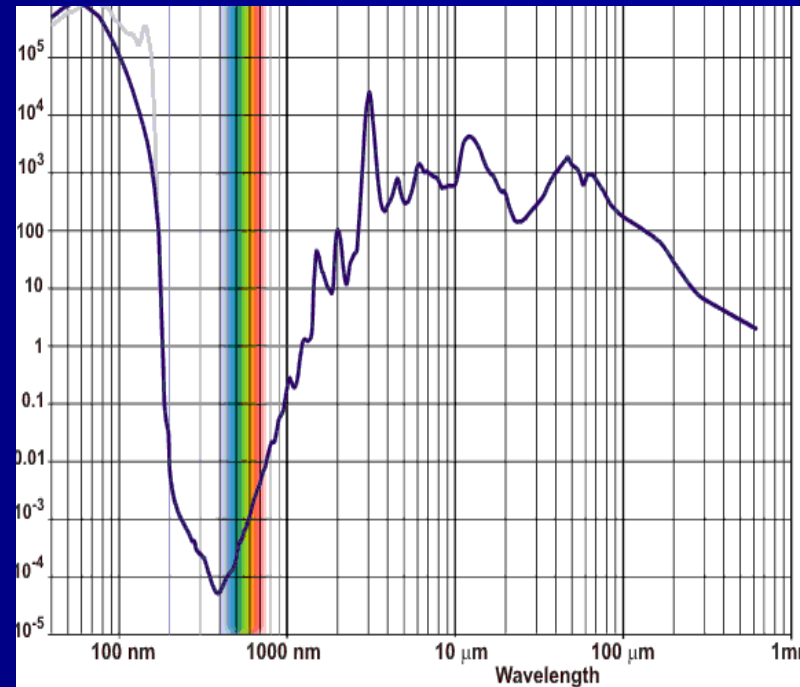
# Water!

Silica absorption (dB/km)



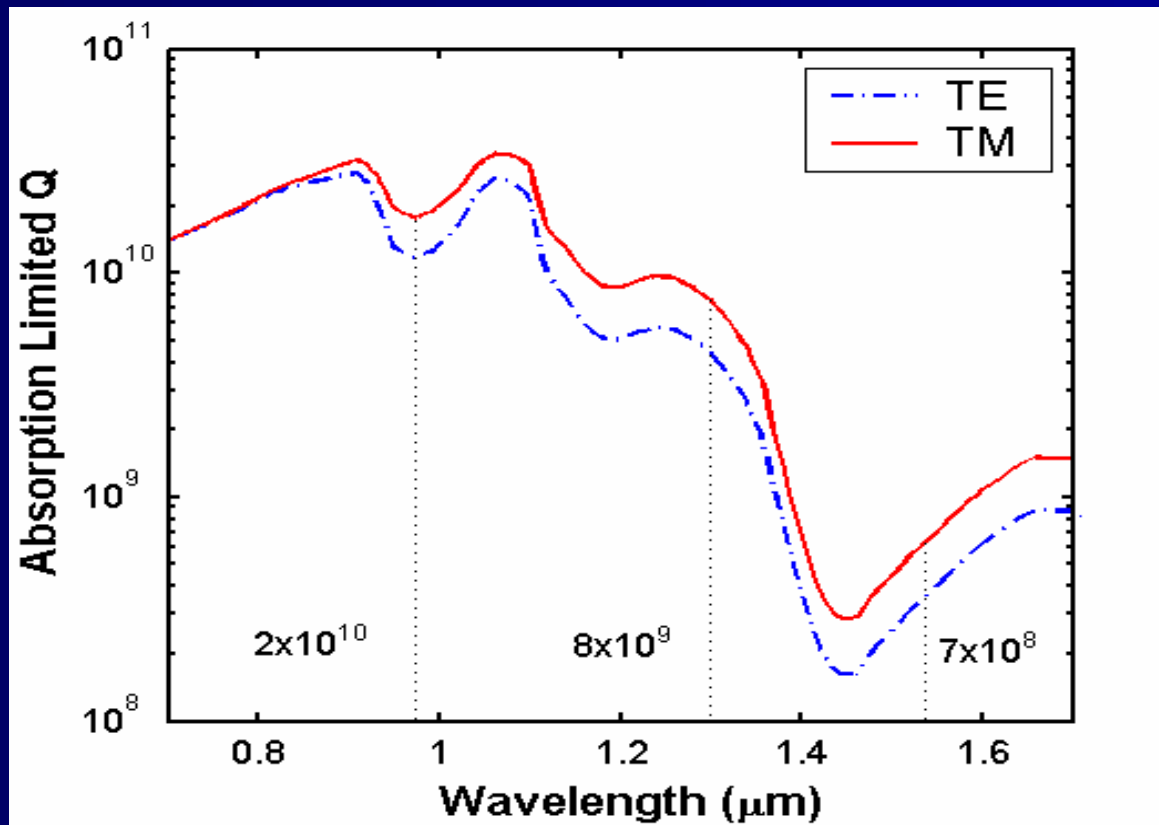
Wavelength

Water absorption (1/cm)



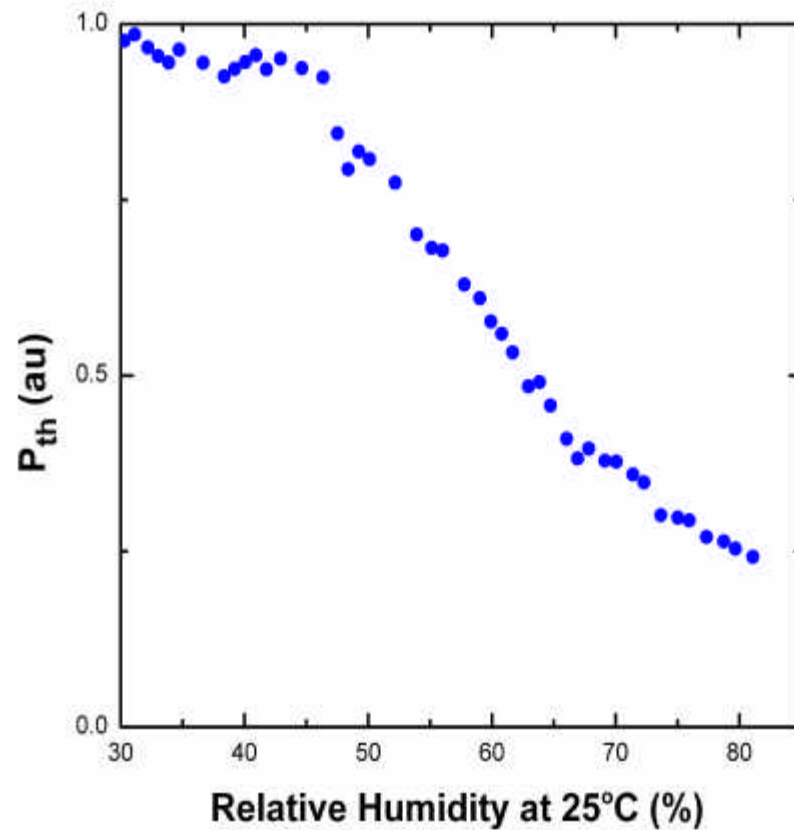
Wavelength

# Absorption Limited Q

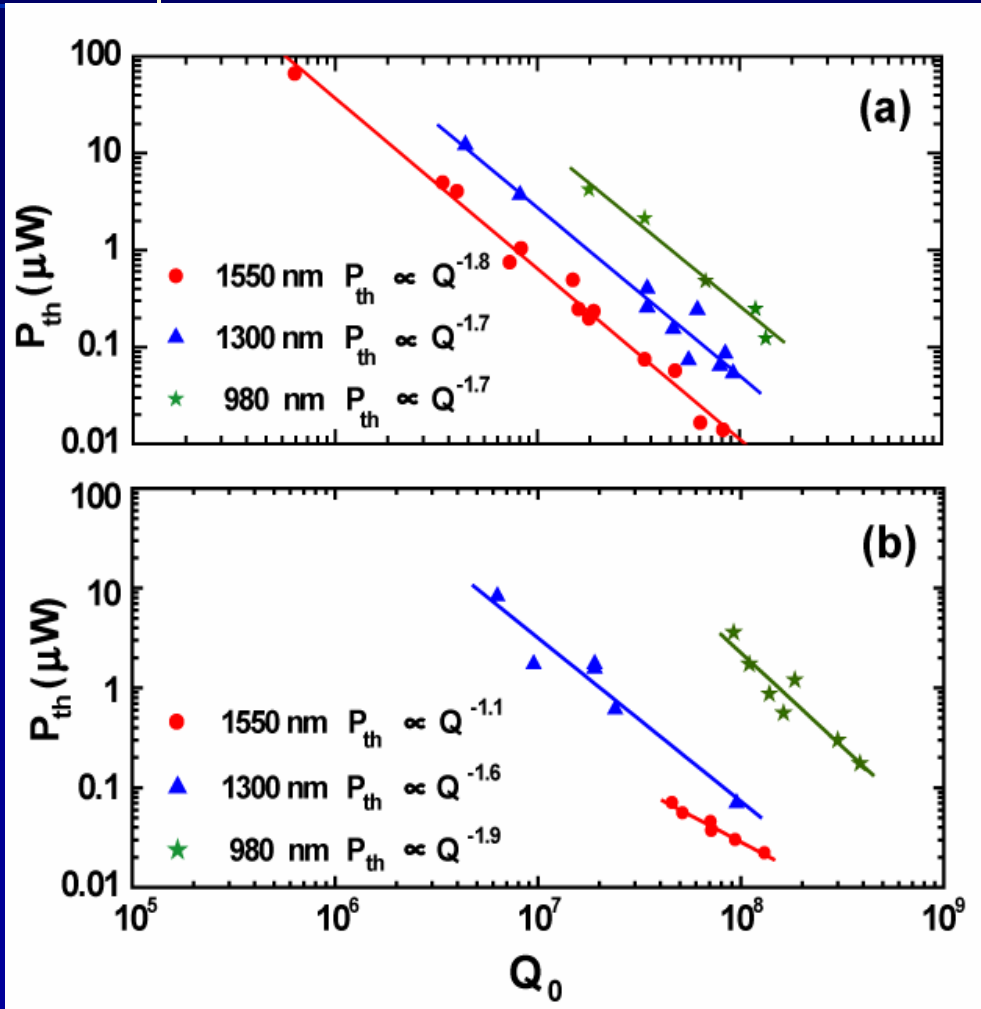


$$P_{th} \propto \frac{n_0^2 C_p}{Q a t_{thermal}} \frac{1}{dn/dT}$$

# Sensing The Humidity



# Q behavior of Threshold power



$$P_{th} \propto \frac{1}{Qa}$$

$$a = \frac{\text{absorption}}{\text{absorption} + \text{scattering}}$$

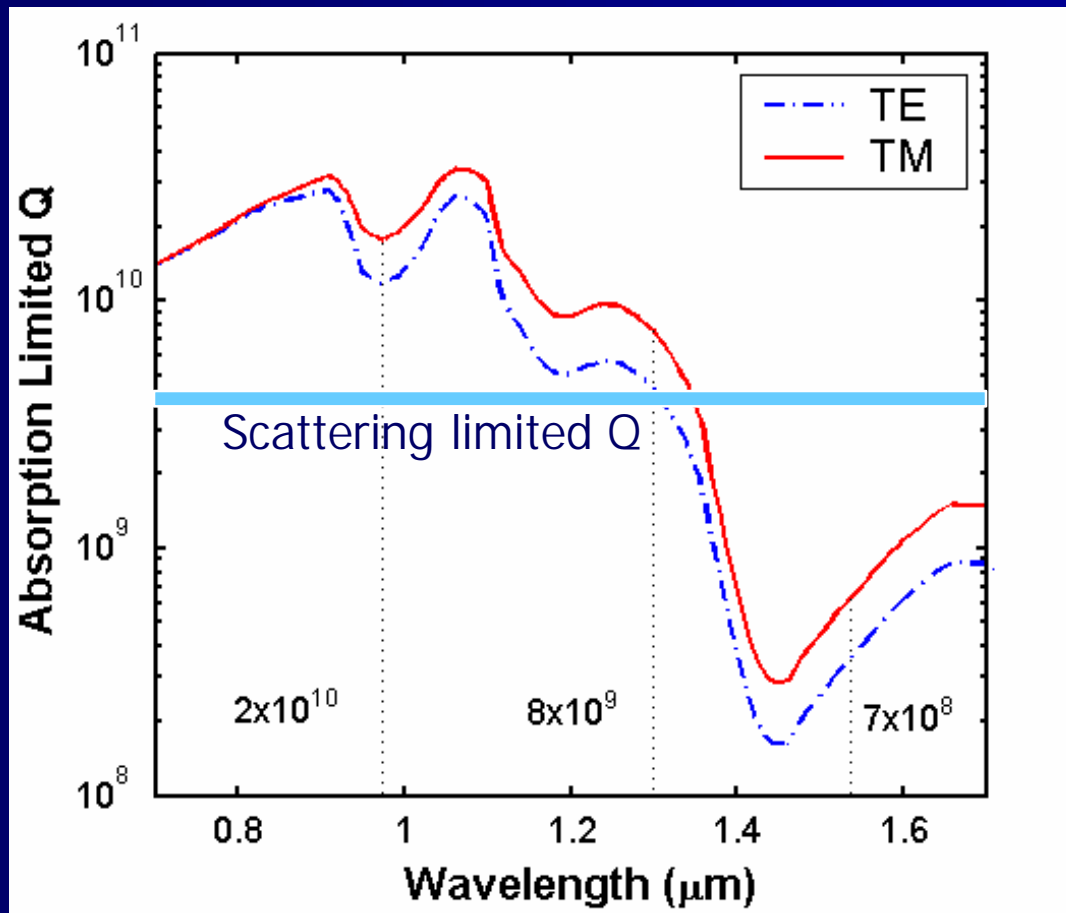
*absorption*  $\ll$  *scattering*  $\Rightarrow a \propto Q$

$$P_{th} \propto \frac{1}{Q^2}$$

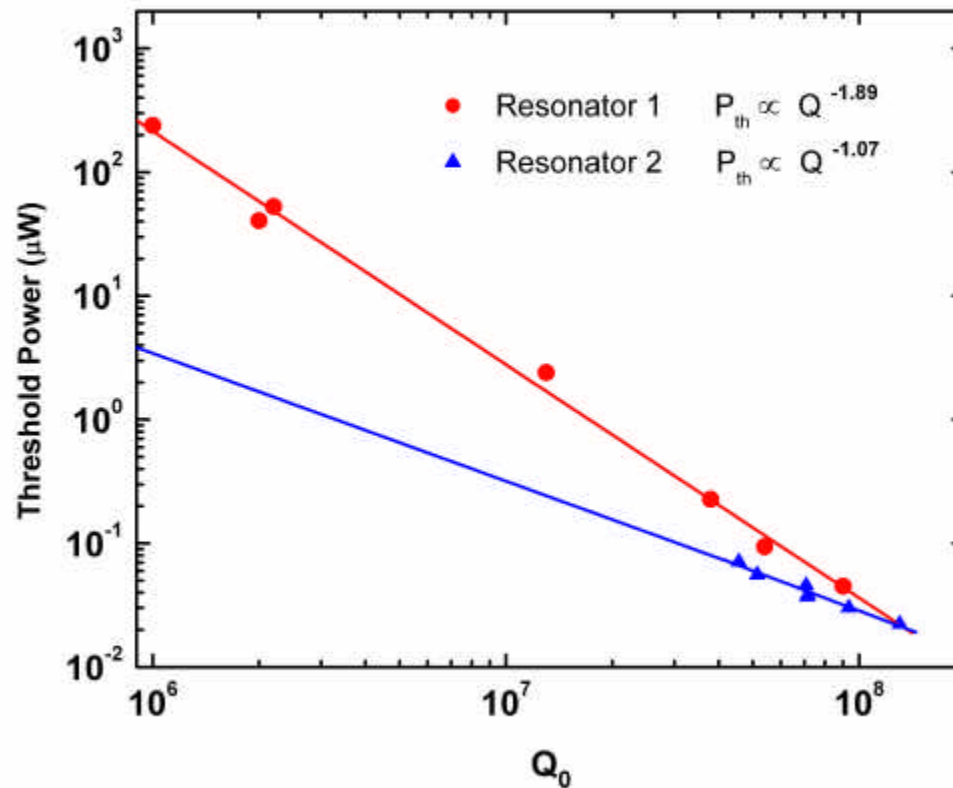
*absorption*  $\gg$  *scattering*  $\Rightarrow a = 1$

$$P_{th} \propto \frac{1}{Q}$$

# Absorption Limited Q



# Quick Test for Loss Characterization



# Conclusions

- measurement of nonlinear thermal effects in micro-resonators as an effective method to characterize different loss mechanisms in these structures
- information can be obtained about the surface chemistry of the cavity through a combination of spectral measurements of threshold power and  $Q$
- real time monitoring of thermal properties and quality factor can be beneficial in studying the dynamics of interaction between the resonator surface and its environment.

*Thanks for your attention*

*More information :*

*Applied Physics Letters , October 2004*

<http://www.its.caltech.edu/~vahalagr>

