Sensitivity Limits

High force and force-derivative sensitivity can be obtained with soft cantilevers having a high resonance frequency and a high-quality factor. Low temperatures are beneficial. The sensitivities for forces [N/sqrt(Hz)] and force-derivative [(N/m) / (sqrt(Hz)·m] are given by

$$F|_{\min} = \sqrt{\frac{4k_B T k_c B}{2\pi f_c Q}} \quad (1)$$

$$\left.\frac{\partial F}{\partial z}\right|_{\min} = \frac{1}{A}\sqrt{\frac{4k_B T k_c B}{2\pi f_c Q}} \quad (2)$$

where k_B is the Boltzmann constant, T the temperature, k_c the cantilever force constant, B the measurement bandwidth, f_c the resonance frequency of the cantilever, and Q the quality factor of the cantilever.

Note for a cantilever with a resonance frequency of 50 kHz, a force constant of 0.3 N/m and a quality factor of $Q = 10^6$, a force sensitivity of 125 aN/sqrt(Hz) is obtained at room temperature!