Ultrahigh-Q mechanical oscillators through optical trapping\textsuperscript{1}

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Rapid advances are being made toward optically cooling a single mode of a micro-mechanical system to its quantum ground state and observing quantum behavior at macroscopic scales. Reaching this regime in room-temperature environments requires a stringent condition on the mechanical quality factor $Q_m$ and frequency $f_m$, $Q_m f_m \gtrsim k_B T_{\text{bath}}/\hbar$, which so far has been marginally satisfied only in a small number of systems. Here we propose and analyze a new class of systems that should enable unprecedented $Q_m f_m$ values [1-3]. The technique is based upon using optical forces to “trap” and stiffen the motion of a tethered mechanical structure [3], thereby freeing the resultant mechanical frequencies and decoherence rates from underlying material properties. We have lithographically fabricated a diverse set of planar structures in Silicon Nitride, made measurements of their optical and mechanical properties, and compared these results to numerical models by finite element analysis.

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