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Photonic actuation and detection of higher order modes in nanomechanical resonators

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All-optical actuation and detection of nanomechanical devices has emerged as a promising transduction technique with high displacement sensitivity¹⁻³. However, symmetric mechanical modes are difficult to detect with integrated photonics because the symmetry causes a zero effective index shift. Detection of higher order modes, including symmetric modes, is desirable for sensing applications since higher order modes provide additional information about analyte mass and position⁴. We demonstrate optical transduction of higher order mechanical modes, including even modes, in nano-optomechanical doubly clamped beams. Doubly clamped beams are fabricated with a step in the underlying substrate to cause a non-zero effective index change. A theoretical model of the optical transduction responsivity is developed to improve our understanding of the system. The thermomechanical noise floor of the first through third modes is observed. With an optical driving force, we measure the first through fifth mechanical modes. The displacement sensitivities of the first through third modes are 170 fm/Hz^{1/2}, 153 fm/Hz^{1/2}, and 140 fm/Hz^{1/2}. The trend of improved sensitivity with increasing mode number is verified by our theoretical model. The increased sensitivity of higher order modes is an important result for future sensing experiments.

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