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Colocalized mechanical multimodes in a single optomechanical crystal cavity

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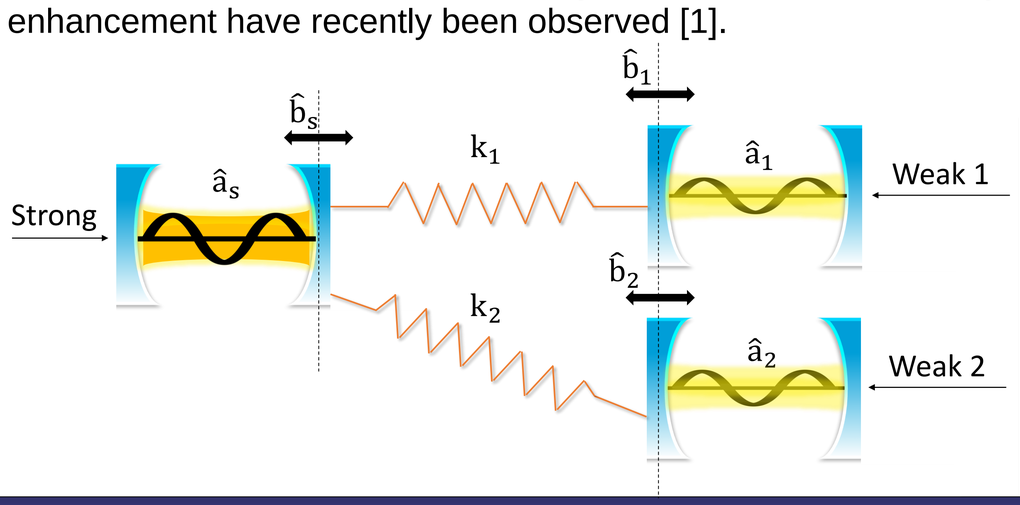
ABSTRACT

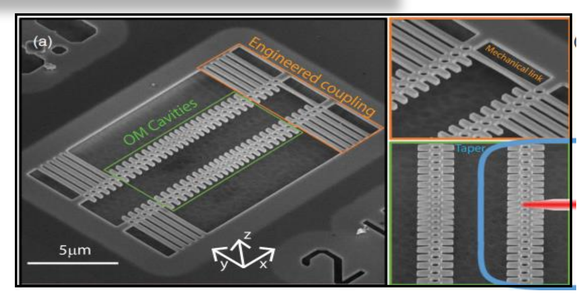
We present an experimental demonstration of an optomechanical crystal cavity that holds multiple confined mechanical modes coupled to the same optical field when increasing the number of transition cells surrounding it. Through this design, several GHz mechanical modes placed in a complete phononic bandgap can be transduced via optomechanical interaction.

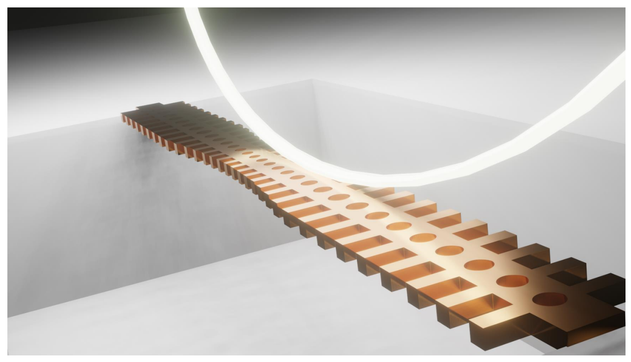
FUNDAMENTALS: OPTICAL AND MECHANICAL MODES INTERACTION

Usually, optomechanical cavities are designed to bear a single mechanical mode when an optical field is coupled to the cavity. However, phenomena involving one optical mode coupled to various mechanical modes like synchronization or stability enhancement have recently been observed [1].



In most of those systems, the involved mechanical modes are not confined into the same physical structure, thus resulting in larger and complex systems [2]. This requires the existence of a physical link between cavities to couple the mechanical modes.

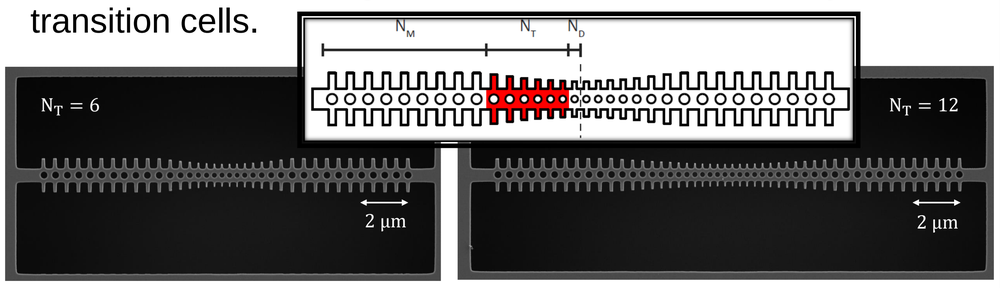




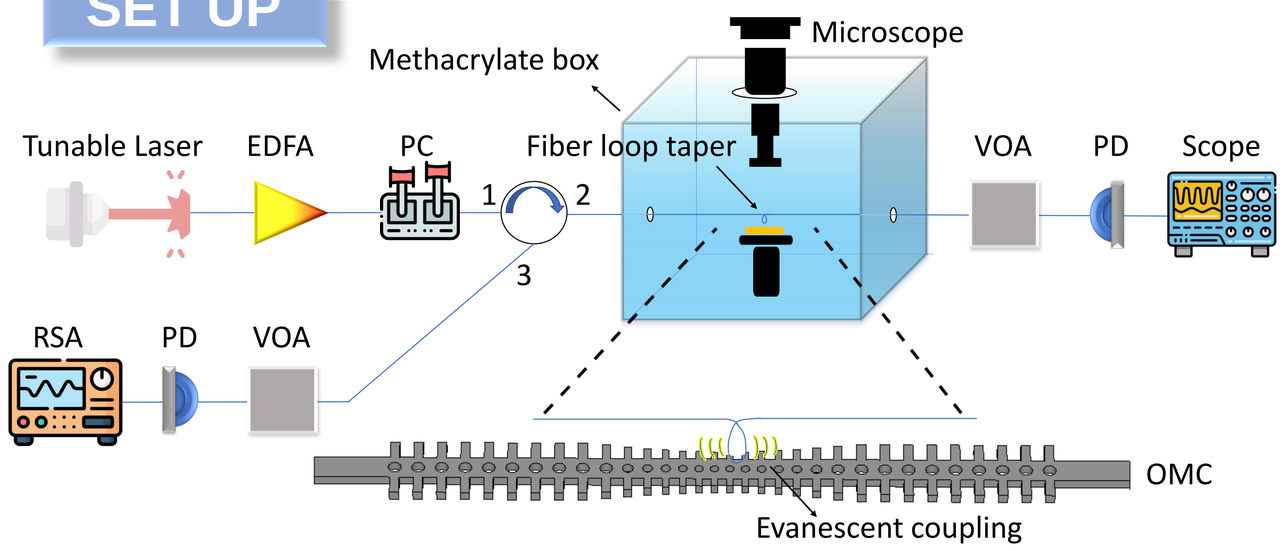
In this context, we propose and demonstrate an optomechanical crystal cavity that simultaneously holds several confined mechanical modes as a function of the cavity design. By adding transition cells to the cavity, new GHz mechanical modes appear.

CAVITY DESIGN

The cavity unit cell consists of a hole and two lateral corrugations whose mechanical modes vibrate at around 4 GHz, where the cavity mirror intentionally has a full phononic bandgap. The crystal is composed by 11 periodical mirror unit cells and a defect region of one cell surrounded by variable transition cells.



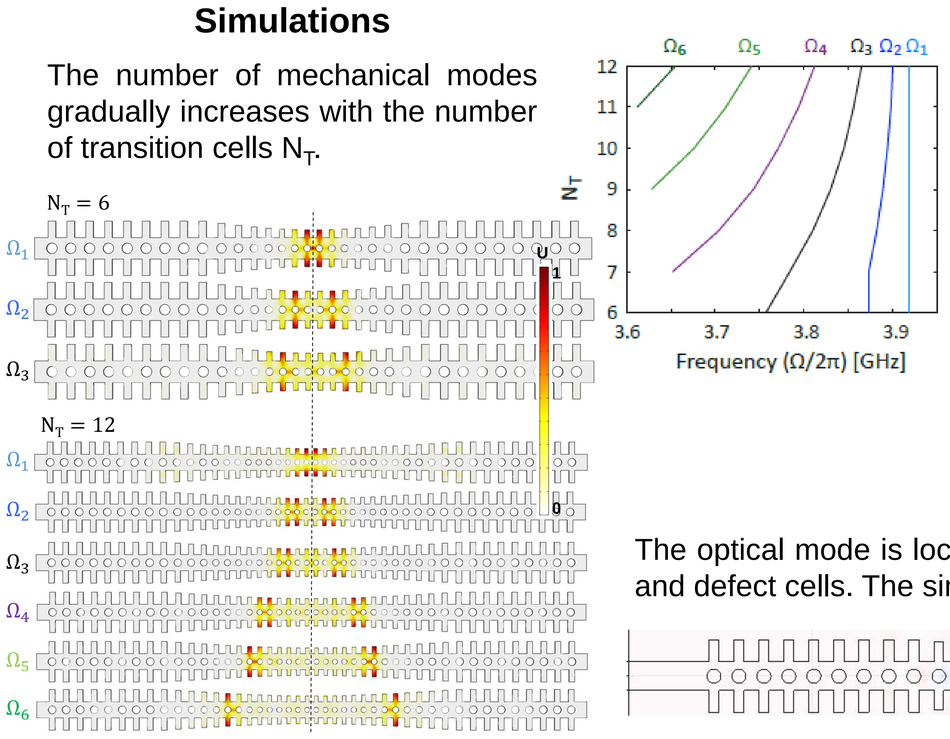
SET UP

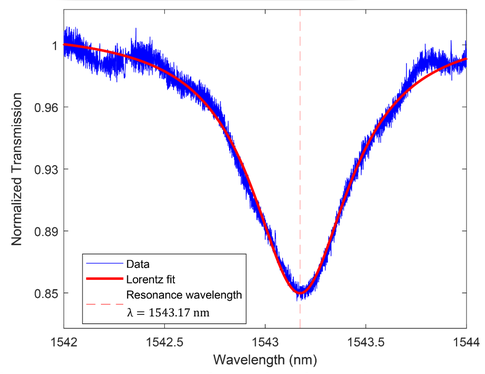


RESULTS

Simulations

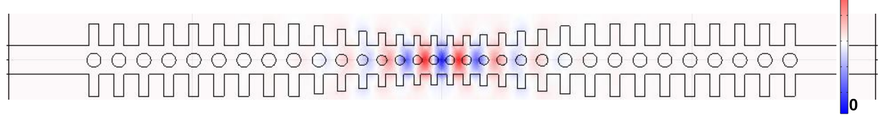
The number of mechanical modes gradually increases with the number of transition cells N_T.

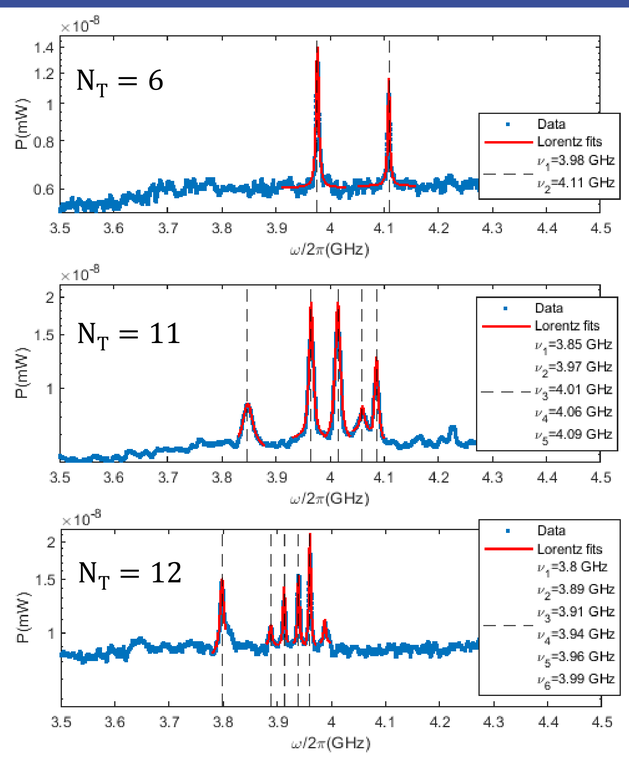




The experimental optical and mechanical modes show the simulated behavior.

The optical mode is localized between the holes of the transition and defect cells. The simulated wavelength is $\lambda = 1550\ \mathrm{nm}$.





CONCLUSIONS

We have been able to experimentally transduce the mechanical multimode response through the excitation of the optical resonance of an OM crystal cavity by evanescent light coupling. Besides applications in synchronization or stability enhancement, this systems may have applications in multimode phonon lasers, which has recently been demonstrated that multiple confined modes in a single structure can also get into a self-sustained regime [3].

REFERENCES & ACKNOLEDGEMENTS

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