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Nanophotonics Coupling Nanomechanics to the Play in the Surface of Nanomaterials

Dongmei Dong*

Department of Physics and Astronomy, Rowan University, NJ, US

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***Corresponding author:** Dongmei Dong, Department of Physics and Astronomy, Rowan University, NJ, US

Abstarct

Glance at nature, light is responsible for all life on Earth; In the physical world, light carries energy and information. Nowadays, thanks to the tremendous progress in the field of nanotechnology, light can be confined to a sub-wavelength spatial dimension to intensify the interactions between light and matter, giving birth to the area of nanophotonics. Nanophotonics has a promising future because of the scientific thirst for knowledge and the need for multimodal, energy efficient, and compact technologies in society today. Particularly, the emergence and advancement of metamaterials, further enhance the strength of the local field intensity due to the localized surface effects, e.g., plasmonic resonance; Yet, realizing the maximum potential of such intensified interactions requires a platform that is capable of quantifying time-dependent nanoscale motion precisely. Thus, the coupling of nanophotonics and nanomechanics on a dynamic cantilever resonator with the nanomaterials surface as the media is expected to envision the ongoing interesting phenomenon and advance the scientific discoveries across disciplines.

Keywords: Nanophotonics; Metasurface; Nanomechanics; Photonic platform

Introduction

Recent explosive growth in nanophotonics, ignited by the rapidly developing nanotechnologies, i.e., metasurfaces, plasmonic nanostructures, has demonstrated light exhibits intensified light-matter interactions with sub-wavelength structures. Such exotic behaviors not only manifest the importance of unprecedented optics but suggest the possibility of real-world applications [1]. For wide practical applications, enabling the nanophotonic platform dynamically tunable is one of the most challenging yet important tasks. The pioneering efforts focus on utilizing special phase change materials [2] or tuning metasurface units by exploiting complex 2D beams [3]. In this opinion, the dynamic control of nanophotonics is facilitated by introducing cantilever-based mechanical degrees of freedom to the otherwise static photonic platform, complementary to the current optical and electrical changes, giving rise to new figures of merit of transducing photons and electrons interaction occurred at the surface of nanomaterials into nanomechanical deviation, with simplicity and efficiency. This nanoscale marriage of nanophotonic and mechanics (Figure 1), discloses not only an innovative hybrid platform, but also an in-situ Operando envision nanosystem with real-time orthogonal feedback due to the simultaneous multimodal sensing capabilities of cantilever.

Potential Impact

Given that nanophotonics is a relatively new field, new scientific discoveries concerning its interaction with nanomaterials will have a substantial impact on the development of new technologies. If experimentally implemented, the tiny cantilever (in micro- nano dimension) responds very sensitively to applied optical force and photothermal force, which would enable diverse applications relying on the detection of very weak signals, even to the level of single quanta, i.e., electronic spin qubits induced weak magnetic force can be converted to a detectable electro- or opto-signal. Such mechanical quantum transducer with quantized motion is expected to encode quantum information on the high-Q factor (10^5-10^6) cantilever resonator [4], opening new avenues to visualize quantum mechanics and assist in quantum communication. The versatile applications regarding extraordinary molecular sensing and infrared heat energy generation through such platform will be accessible in the community even sooner supported by the following approaches:

a) To validate optomechanical coupling: Weigh near-field optical forces on a mechanical scale beyond theoretical calculations would be practical. Attributed to the momentum exchange of photons and electrons, the enhanced optical forces in the vicinity of plasmonic and other metastructures can be quantified by the cantilever beam, in both mechanical deflection (static mode) and resonant frequency shift (dynamic mode).

b) To manipulate photothermal effects: Illuminating the infrared light can obtain traces of metastable molecular recognition through the photothermal induced nanomechanical effect of the bi-material cantilever with thermal expansion coefficients mismatched, superior to FTIR bounded by opto-output loss following the Lampert Beer Law. Coupling nanophotonics holds exciting potential for extraordinary sensing applications based on photo-thermo mechanical effects on the cantilever, and also for heat-mediated chemical processes in industry by shining the light to boost the energy efficiency and decarbonization.

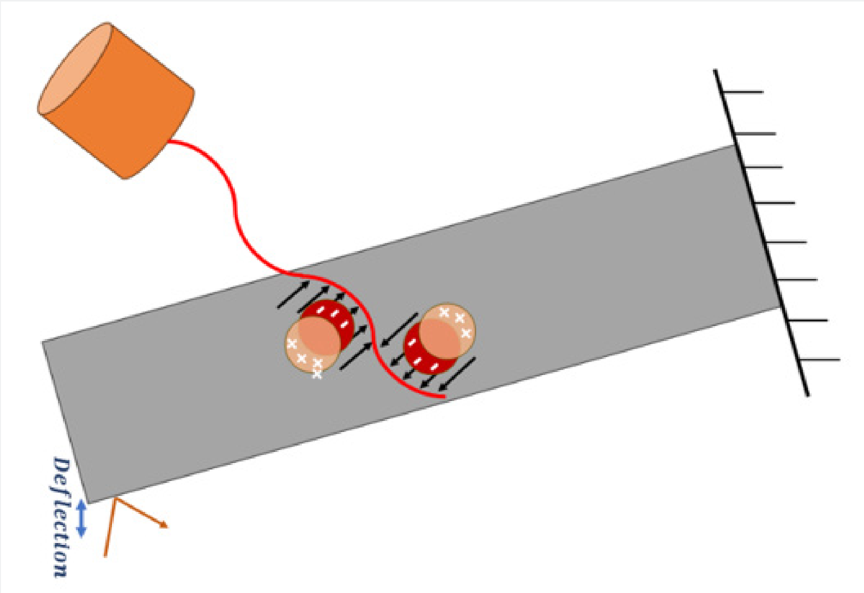

Figure 1: Illustration of nanophotonics coupling nanomechanics on a photo-thermo mechanical cantilever.

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References

1. Koya AN, Cunha J, Guerrero BKA, Garoli D, Wang T, et al. (2021) Plasmomechanical systems: principles and applications. Advanced Functional Materials 31(41): 2103706.
2. Prabhathan P, Sreekanth KV, Teng J, Ko JH, Yoo YJ, et al. (2023) Roadmap for phase change materials in photonics and beyond. Iscience 26(10): 107946.
3. Kim SI, Park J, Jeong BG, Lee D, Yang KY, et al. (2022) Two-dimensional beam steering with tunable metasurface in infrared regime. Nanophotonics 11(11): 2719-2726.
4. Kurizki G, Bertet P, Kubo Y, Mølmer K, Petrosyan D, et al. (2015) Quantum technologies with hybrid systems. Proceedings of the National Academy of Sciences 112(13): 3866-3873.

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