Publication List

1. B. Qiang, A. M. Dubrovkin, H. N.S. Krishnamoorthy, Q. Wang, C. Soci, Y. Zhang, J. Teng, Q. J. Wang, “High Q-factor controllable phononic modes in hybrid phononic-dielectrics” (Submitted)

2. B. Qiang, A. M. Dubrovkin, H. N.S. Krishnamoorthy, C. Soci, Q. J. Wang, “Hybrid dielectric-phonon metamaterial in mid-infrared” (Submitted)

3. *A. M. Dubrovkin*, B. Qiang, H. N. S. Krishnamoorthy, N. I. Zheludev and Q. J. Wang, "Ultra-confined surface phonon polaritons in molecular layers of van der Waals dielectrics", *Nature Communications*, 9, 1726, 2018.

4. *Y. Zeng*, G. Liang, B. Qiang, K. Wu, J. Tao, X. Hu, L. Li, A. G. Davies, E. H. Linfield, H. K. Liang, Y. Zhang, Y. Chong, and Q. J. Wang, "Two-dimensional multimode terahertz Random lasing with metal pillars", ACS Photonics, 5, 2928−2935, 2018.

5. *Y. Zeng*, G. Liang, B. Qiang, B. Meng, H. K. Liang, S. Mansha, J. P. Li, Z. H. Li, L. H. Li, A. G. Davies, E. H. Linfield, Y. Zhang, Y. Chong, and Q. J. Wang*, “Terahertz Emission from Localized Modes in One-Dimensional Disordered Systems”, **Photonics Research**, 6, 117-122, 2018.(invited paper)

6. *T. Liu*, D. Qiu, T. Yin, C. Huang, G. Liang, B. Qiang, Y. Shen, H. Liang, Y. Zhang, H. Wang, X. Shen, D. W. Hewak, and Q. J. Wang, "Enhanced light-matter

interaction in atomically thin MoS2 coupled with 1D photonic crystal nanocavity", *Optic Express*, 25, 14691-14696, 2017.

7. *Meng*, B. Qiang, E. Rodriguez, X. Hu, G. Liang, and Q. J. Wang, "Coherent emission from integrated Talbotcavity quantum cascade lasers", *Optic Express* 25, 3077-3082, 2017.

Abstract

The development and progress in nanophotonics is powered by the discovery of new materials and new methods to squeeze electromagnetic wave like into smaller volume and minimize the its loss as much as possible. The large optical mode confinement and low loss are indispensable properties for a vast range of applications, such as cavity quantum electrodynamics, nonlinear high harmonic generation, integrated optical circuit, high sensitivity sensors, super resolution imaging and photon-induced chemical or biological process. Each spectral region has different material platform to achieve the holy grail. The most popular examples are surface plasmon resonance in visible to near infrared, graphene in infrared and superconductors in terahertz. Phonon resonance in mid-infrared also demonstrates superb properties in terms of low-loss and high confinement.

During my Ph.D. candidature period, we have made some contribution to explore the properties of phononic-dielectric hybrid material system. In chapter 3, we summarized the experiment skills, material propertie, and some preliminary results. These are the foundation for the main works presented in this thesis. In chapter 4, we explore the limit of confinement that the SiC-MoS_2 heterostructure can achieve. By exfoliated MoS_2 flakes of different thickness onto the SiC substrate, we analyzed the how the confinement of the EM mode energy depends on the thickness and incident wavelength. In chapter 5, we showed that fabricating nanostructures using FIB milling will damage the crystalline lattice. As an alternative approach, we proposed a new method to excite

the phonon resonance using a nanostructured dielectric layer of deep subwavelength thick. We showed the hybrid dielectric-phononic scheme has stronger resonance than the phononic nanostructure, when the thickness is thin. We tested our proposed metamaterial through experiment and evaluated its performance as a refractive index sensor. In chapter 6, we investigated the mode interaction and coupling between the localized hyrid phononic-delectric resonance with the propagating surface polariton. Our results show that the coupling strength can be tailored by the changing the germanium ribbon width. The mode energy distribution in near field and the resonant wavelength can be controlled by the coupling between the modes. All these results presented in this thesis will be useful in designing hybrid dielectric-phononic devices.