Nanocavity induced by atomically thin transition metal dichalcogenide in photonic crystal waveguide

°C.F. Fong[1], D. Yamashita[2,3], N. Fang[1], S. Fujii[2,4], Y.-R. Chang[1], T. Taniguchi[5], K. Watanabe[6] and Y. K. Kato[1,2]

[1]*Nanoscale Quantum Photonics Laboratory, RIKEN Cluster for Pioneering Research, Saitama 351-0198, Japan*

[2]*Quantum Optoelectronics Research Team, RIKEN Center for Advanced Photonics, Saitama 351-0198, Japan*

[3]*Platform Photonics Research Center, National Institute of Advanced Industrial Science and Technology (AIST), Ibaraki, 305-8568, Japan*

[4]*Department of Physics, Faculty of Science and Technology, Keio University, Yokohama, 223-8522, Japan*

[5]*Research Center for Materials Nanoarchitectonics, National Institute for Materials Science, 1-1 Namiki, Tsukuba 305-0044, Japan*

[6]*Research Center for Electronic and Optical Materials, National Institute for Materials Science, 1-1 Namiki, Tsukuba 305-0044, Japan*

Email: cheefai.fong@riken.jp

Photonic crystal (PhC) cavities can be formed by depositing materials onto PhC waveguides post-fabrication to modulate the local refractive index. Previous studies suggested that ultrahigh Q-factor PhC cavities could be formed with a small local refractive index modulation of ~0.1% [1, 2]. However, experimental attempts to create such cavities by depositing poly(methyl methacrylate) (PMMA) onto GaAs PhC waveguides were unable to achieve ultrahigh Q cavities because of the thick polymer layer [3]. Another approach of placing nanowires along the PhC waveguide to induce the formation of nanocavities have also been reported [4, 5]. Alternatively, 2D materials with their atomically thin nature represent a novel platform to realize the small refractive index modulation to induce high Q nanocavity in a PhC waveguide. In this work, we report the observation of high Q-factor nanocavities formed by placing atomically thin transition metal dichalcogenide (TMDC) flakes onto PhC waveguides.

We first performed finite element method (FEM) simulations and verified that even monolayer TMDC flakes could induce the formation of nanocavities in silicon (Si) PhC waveguides, with theoretical Q-factors of the order of 10^6. We then transferred mono- to few-layered WSe_2 flakes onto the Si PhC waveguides and successfully observed the formation cavity modes in the transmission spectra (Fig. 1).

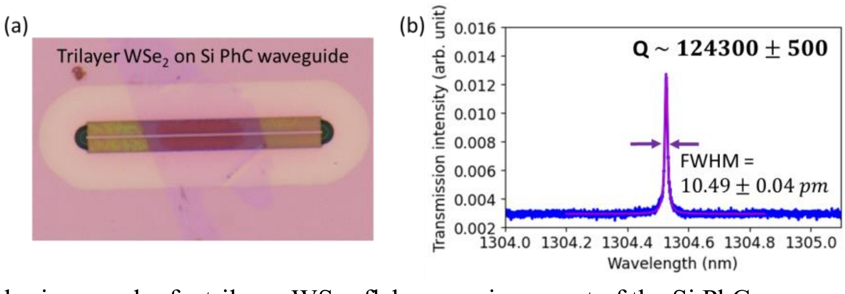

Fig. 1 (a) Optical micrograph of a trilayer WSe_2 flake covering a part of the Si PhC waveguide. (b) Transmission spectra showing the cavity mode with a Q-factor of the order of 10^5.

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