Demonstration of enhanced second-harmonic generation in a SiC photonic crystal waveguide-coupled nanocavity using a heterointerface

Kyoto Univ. [1], Sungkyunkwan Univ [2], °H. Kim[1,2], B. S. Song[1,2], T. Asano[1], S. Noda[1]
E-mail: songwiz@skku.edu, snoda@kuee.kyoto-u.ac.jp

Photonic crystal waveguide-coupled high-*Q* nanocavities provide not only highly-dense photonic integrations, but also novel functions such as trapping and emission of photons [1], nonlinear frequency conversions [2], and dynamic control of photons [3]. In principle, there is passing light through a photonic crystal cavity, but the passed light can be fed again to the cavity by using a heterointerface with high reflectance, which leads to improvement of photonic crystal devices' efficiency without degrading high-*Q* factor of the cavity [4]. So far, the applications of the heterointerfaces have been limited to linear optical devices such as add-drop filters [4-6]. However, it is considered that the heterointerfaces are also useful for nonlinear optical devices [7]. Here, we demonstrate the enhancement of nonlinear optical effect of second-harmonic generation (SHG) in a SiC photonic crystal waveguide-coupled nanocavity by using a heterointerface. Figure 1 shows the fabricated SiC photonic crystal waveguide-cavity system with a heterointerface. The cavity is formed by modulating the lattice constants as $a_1 = 530$ nm, $a_2 = 532.5$ nm, and $a_3 = 535$ nm. The input waveguide with the width $W_{in}=0.69\sqrt{3}a_1$ (~633.75 nm) is placed on the 6 row ($3\sqrt{3}a_1$) from the cavity. In addition, a heterointerface is formed by reducing the width of the waveguide from 633.75 nm to 505 nm as shown in the figure. A reference sample without a heterointerface is also prepared for the comparison. Figure 2(a) shows measured SHG spectrum of the cavity under the excitation at the fundamental resonance (1556.8 nm). The center wavelength of SHG is exactly half of the fundamental resonant wavelength. The *Q* factor of the cavity for the fundamental mode is as high as 7.0 x 10^5. Figure 2(b) shows the relations between the powers for the fundamental light in the waveguide and the SHG powers in the cavity for samples with and without the heterointerface. The relations show typical quadratic SHG characteristics. More importantly, the SHG intensity of the cavity with a heterointerface is 11 times larger than that of the reference sample without a heterointerface. The experimental result agrees well with theory. Details will be presented in the conference.

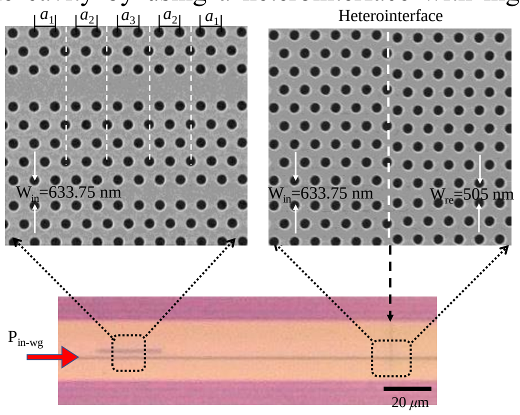

Fig. 1 Optical and SEM images of the fabricated SiC photonic crystal waveguide-coupled cavity.

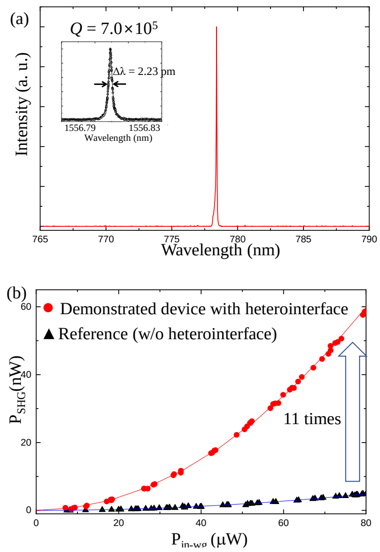

Fig. 2 Measured (a) SHG (inset: fundamental) spectrum. (b) Relation between input power and SHG power.

Ref: [1] S. Noda et al, Nature 407, 608 (2000). [2] B. S. Song et al, Optica 6, 991 (2019). [3] Y. Sato et al. Nat. photonics 6, 56 (2012). [4] B. S. Song et al., Phys. Rev. B 71, 19501 (2005). [5] H. Takano et al., Opt. Express 14, 3491 (2006). [6] Y. Ooka et al., Opt. Express 25, 1521 (2017). [7] H. Kim et al, Opt. Lett. 44, 1837 (2019).