Dependence of second-harmonic generation efficiency on the *Q* factor of SiC photonic crystal nanocavities

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A photonic crystal (PC) nanocavity is promising for the enhancement of nonlinear optical effects including second harmonic generation (SHG), differential frequency generation, and parametric down conversion because of its high quality (*Q*) factor and small modal volume. In particular, SiC-based PC nanocavities have great potential owing to sufficient second- and third-order nonlinear optical coefficients, inhibition of two-photon absorption at telecommunication wavelength, and transparency at visible wavelength.[1)] We have recently realized high-*Q* SiC nanocavities with *Q* factors of the order of 10^5, and reported high normalized SHG conversion efficiency (η_{SHG}) larger than 1000 %/W.[2)] However, the relation between the *Q* factor and η_{SHG} has not been investigated experimentally although larger enhancement of nonlinear effects is theoretically expected for higher *Q* factor.[3)] In this work, we experimentally investigate η_{SHG} in SiC-based PC heterostructure nanocavities with various *Q* factors. Figure 1 shows the structure of nanocavities used for the measurement. The resonant wavelengths and *Q* factors of the fundamental modes of the prepared four samples are 1500~1515 nm and 2~6×10^5, respectively. Fig. 2 shows the SHG characteristics of a SiC cavity with a *Q* factor of 4.4×10^5. We evaluated fundamental light power (P_{fund}) from the power transmitted through the coupling waveguide and the experimentally obtained coupling efficiency between the waveguide and the cavity. SHG light power (P_{SHG}) was evaluated from the integrated intensity of the image measured by a Si-CCD camera (inset) and the collection efficiency of the experimental setup. The normalized SHG efficiency ($\eta_{SHG}=P_{SHG}/P_{fund}^2$) was evaluated to be 1700%/W for this cavity. η_{SHG}'s measured for the four cavities are summarized in Fig. 3, where η_{SHG} increases with an increase of *Q* factor. A very high η_{SHG} of 1900%/W has been achieved in a cavity with a *Q* factor of 5.6×10^5. Details including a theoretical discussion will be presented at the conference.

Ref: 1) S. Yamada, et. al, Opt. Lett. **39**, 1768 (2014). 2) Y. Yamaguchi, et. al, The 77th JSAP Autumn Meeting 22a-S621-10 (2016). 3) H. Kim, et. al, J. Opt. Soc. Am **B 33**, 2010 (2016).

Acknowledgement: This work was supported by JSPS KAKENHI (15H03993), and the National Research Foundation of Korea (2017R1A2B4003374) grant funded by the Ministry of Science and ICT.

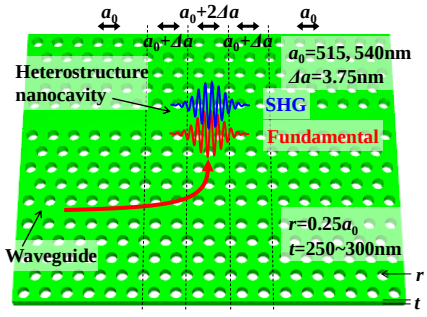

Fig. 1: Schematic of SiC-based two-dimensional PC nanocavity used for the measurement.

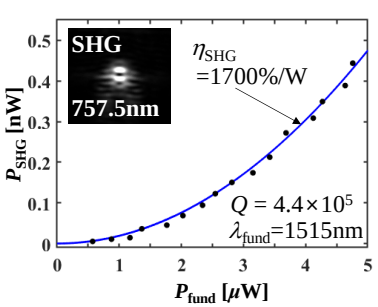

Fig. 2: SHG generation characteristics of a cavity with a *Q* factor of 4.4×10^5. Inset: the nearfield image of SHG emission.

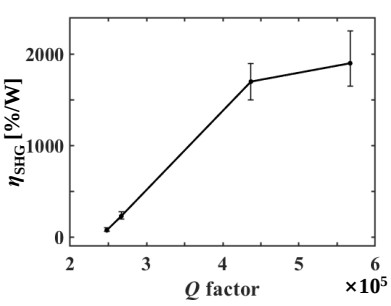

Fig. 3: Experimental dependence of normalized SHG conversion efficiency (η_{SHG}) on the *Q* factor.