SiC フォトニック結晶ナノ共振器の高 Q 値化に向けた基礎検討(2)
Basic study on SiC-based high Q photonic crystal nanocavity (2)

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We have demonstrated that photonic-crystal (PC) nanocavities based on Silicon Carbide (SiC) have many advantageous properties over Si nanocavities such as suppression of two-photon absorption [1] and ultra-broad band operation [2]. In addition, we have reported various nonlinear phenomena [3] in the SiC nanocavities. However, the experimental Q factors (~10^4) of the fabricated nanocavities have proved to be much lower than the design Q factors, and in the previous report we have confirmed that material absorption is the major origin of the Q factor degradation [4]. Here, we report the reduction of the material absorption by high temperature annealing, and demonstrate the improvement of the Q factor of SiC PC nanocavities.

It is considered that the material absorption is originated from the defect states generated within the SiC slab during the fabrication process of the SiC-on-insulator (SiCOI) substrates. In order to reduce the defect states and to improve the Q factors, we tried high-temperature annealing over 1300 °C because it is known in the field of SiC-based electronic devices that some kinds of defects in SiC can be eliminated by such process [5]. We cut out two SiCOI pieces (5mm × 8mm) from the same SiCOI wafer (360 nm-thick SiC/1500nm-thick SiO2/380μm-thick Si), and annealed one of the pieces at 1400 °C for 30min. We fabricated PC nanocavities using the annealed and non-annealed SiCOI pieces for comparison, where five types of different nanocavity designs with the vertical Q factors of ~10^6 were adopted (Fig. 1(a)). The Q factor of each sample was measured and Fig. 1 (b) shows the result. It is seen in the figure that nanocavities fabricated using SiCOI substrates annealed at 1400°C have Q factors of ~12000 while those without the annealing have Q factors of ~7000 in average (1.7 times improvement). Although the experimental Q factors are still lower than the designed Q factors, the result indicates the possibility of further improvement of Q factors based on annealing process. Further details on the other results will be presented at the conference.

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Fig. 1: (a) Schematic of SiC based PC nanocavity structure with D = 0.58a1, t =0.6a1. Here, the lattice constants are set as the follows: a3 > a2 > a1. (b) Q factor with or without annealing (dotted lines: average)