Giant Enhancement of Nonlinear Harmonic Generation in a Silicon Topological Photonic Crystal Nanocavity Chain

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Strongly enhanced third-harmonic generation (THG) by the topological localization of an edge mode in a Su-Schrieffer-Heeger (SSH) chain of silicon photonic crystal nanocavities is demonstrated. The edge mode of the nanocavity chain not only naturally inherits resonant properties of the single nanocavity, but also exhibits the topological feature with mode robustness extending well beyond individual nanocavity. By engineering the SSH nanocavities with alternating strong and weak coupling strengths on a silicon slab, the edge mode formation that entails a strong THG signal similar to that obtained from a single nanocavity is observed, which both show three orders of magnitude enhancement compared with that in a trivial SSH structure. The results indicate that the photonic crystal nanocavity chain can provide a promising on-chip platform for topology-driven nonlinear photonics.

1. Introduction

Taking the inspiration from the quantum Hall effects and topological insulators discovered in condensed matter physics, topological photonics has turned into a rapidly emerging field of research.\cite{1–5} Its main hallmark is the emergence of topologically protected edge states at the interface between photonic structures with distinct topological invariants.\cite{1,2} Such edge states present a solid immunity to local distortions during optical transport,\cite{3–10} which promotes the development of topological platforms for implementing stable and reliable photonic devices such as single-mode low threshold topological lasers\cite{11–19} and chirality-selective routers.\cite{14,7,8,20–24} When optical nonlinearity are taken into account, novel phenomena and advanced functionalities arise, including nonlinearity-induced topological transitions, topological bandgap solitons and robust single-photon sources.\cite{25–34} For instance, relying on spontaneous four-wave-mixing and other nonlinear processes, topologically protected quantum states including the correlated biphoton pairs and entangled states have been proposed and demonstrated.\cite{39–41} Based on the Kerr effect, self-trapped soliton edge modes are predicted under local topological phase transition with high pump power, promising for tunable filters and isolators with eliminated backscattering.\cite{12} In addition, nonlinear harmonic generations by the edge modes of topological photonic structures have also been reported, which enable advanced nonlinear optical imaging of nanostructures with superior contrast and sensitivity.\cite{33,34} Therefore, nonlinear topological photonics is expected to form a favorable ground with novel functionalities for photonic applications.

One of the prototypical and most popular topological photonic systems is the so-called 1D Su-Schrieffer-Heeger (SSH) model formed by a chain of coupling elements under alternating strong and weak coupling strengths, which can support topological edge modes.\cite{35} In photonics, the first SSH lattice and associated edge modes were realized in an optically induced dimer chain of coupled waveguides, where trivial and nontrivial superlattices were readily reconfigured by different terminations of the quasiperiodic photonic structures.\cite{36} The stationary edge modes of the nontrivial SSH lattices have been widely employed to achieve topological lasing by constructing dimer chains of microrings, nanodisks, and photonic crystal nanocavities.\cite{16–19,37} Interestingly, the introduction of nonlinear effects into the photonic SSH lattices has led to a host of novel phenomena, including for example actively controlled topological zero modes, nonlinear spectral tuning, and nonlinear control of PT symmetry and non-Hermitian topological states.\cite{16,38–43} In particular, a pioneering work about the nonlinear harmonic generation in photonic SSH structure was reported by Kruk et al., which is composed of a zigzag array of silicon nanodisks with Mie resonance.\cite{14} The nanoscale silicon nanodisks, as the coupling element of the SSH structure, promise the compact footprint and flexible design of the structure by moving the nanodisks individually. Topological localization of the electric field at the edge of the zigzag array provides multifold enhancement of the third harmonic generation (THG), while enjoys the topological robustness of the edge modes against perturbations.

In this work, we demonstrate strongly enhanced THG in silicon by exciting a topological edge mode of an SSH lattice formed by coupled photonic crystal nanocavities (PCNCs). We show that,
Figure 1. a) Schematic of the finite-sized SSH structure formed by nine coupled PCNCs (A₁B₁A₂B₂...A₅) with alternating weak and strong coupling strengths (γ₁ < γ₂) to support enhanced THG by the topological edge mode. b) Calculated nine eigenvalues of finite-sized SSH structure based on the tight-binding model, showing a topological edge mode locating in the band gap (Δ) established by the topological bulk modes. c) Wave function (|ψ|) of the topological edge mode, where the dashed line is an exponential curve (γ₂/γ₁)⁻ᴺ along the hopping nanocavities Aⱼ.

In such an SSH structure, the edge mode naturally inherits resonant properties of a single PCNC, while it also manifests the topological feature with robustness extending well beyond individual nanocavity. Compared with silicon nanodisks,[34] PCNCs fabricated in a silicon slab have resonance modes with much higher quality (Q) factors, which are promising for narrower resonance linewidth and stronger light−matter interaction. In addition, it is more reliable to construct on-chip optoelectronic devices with PCNCs, including modulators, photodetectors, etc.[44−46] These attributes enable the SSH structure of PCNCs to have potentials in chip-integrated topological photonic circuits. From the fabricated structures, we obtain a strong silicon THG signal from the nontrivial topological edge mode, which is enhanced by more than three orders of magnitude compared to that from a trivial SSH structure.

2. Device Design

Figure 1a displays the schematic of the enhanced THG driven by the topological edge mode of a silicon SSH structure. PCNCs as the coupling elements are arranged to form two sublattices (Aⱼ and Bⱼ) with hopping coupling strengths of γ₁ and γ₂. The finite-sized SSH structure has nine coupled PCNCs, which are separated by one or three rows of air holes to guarantee their alternating coupling strengths (γ₁ < γ₂). The employed PCNCs here are formed by removing three adjacent air holes and shifting the nearest neighbor two air holes outward in a hexagonal photonic crystal lattice, i.e., the L₃ PCNCs.[47]

In the SSH model with odd numbers of sites, the Hamiltonian could be expressed as

\[ H_{\text{odd}} = \sum_{j=1}^{N-1/2} \left( \left( \gamma_1 A_j^\dagger + \gamma_2 A_{j+1}^\dagger \right) B_j \right) + \text{h.c.} \]  

Here, N is the number of sites, which is chosen as 9 in this work. By diagonalizing the Hamiltonian, when γ₁ < γ₂, one can find an edge mode locating in the band gap (Δ) formed by other eight bulk modes and its wave function (|ψ|) dominants at the left terminus, as shown in Figure 1b,c. The open band gap will protect the edge mode against coupling disorders and keep specific wave function distribution characters along the nine sites. The edge mode here could be predicted by the topological invariant in an infinite topological system, called Zak phase (θ_Zak) in the 1D topological system, that is

\[ \theta_{\text{Zak}} = \int_{-\pi}^{\pi} \frac{dk}{\pi} < u_k | \epsilon \partial \epsilon | u_k > = \begin{cases} \pi, & \gamma_{\text{intra}} < \gamma_{\text{inter}} \\ 0, & \gamma_{\text{intra}} > \gamma_{\text{inter}} \end{cases} \]
where $u_k$ is the Bloch wave function. $\gamma_{\text{intra}}$ and $\gamma_{\text{inter}}$ are intra- and intercoupling strengths of the dimer unit $A, B$, which respectively correspond to $\gamma_1$ and $\gamma_2$ in Figure 1a.\(^{[48]}\) For an SSH chain formed by an infinite number of dimer units $A, B$, the intercoupling strength $\gamma_{\text{inter}}$ is weaker than the intercoupling strength $\gamma_{\text{intra}}$, and the system is consequently in a topological nontrivial phase with $\theta_{zak} = \pi$. In contrast, if one considers the dimer $B, A_{\theta=1}$ as a constitutive unit, the intracoupling strength of the dimer is stronger than the intercoupling strength, and consequently the chain turns into a system with a topological trivial phase of $\theta_{zak} = 0$. Therefore, at the interface between the nontrivial chain and surrounding trivial system, such as the terminal site $A_1$ in Figure 1a, there would happen a topological phase transition ($\Delta \theta_{zak} = \pi$), which supports a topological edge mode.\(^{[48]}\)

### 3. Results and Discussions

The proposed SSH structure is fabricated on a silicon-on-insulator substrate with a 220 nm thick silicon layer. The hexagonal lattice of the photonic crystal has a period of $a = 465 \text{ nm}$ and an air-hole radius of $r = 0.29a$. This design supports the resonance modes around near-infrared spectral range with high $Q$ factors. After the electron beam lithography and inductively coupled plasma dry etching, the formed structures in the silicon slab are air suspended by undercutting the buried oxide layer, which ensures the effective vertical confinements of the resonance modes. Figure 2a, b displays scanning electron microscopy (SEM) images of the fabricated single PCNC and non-trivial SSH structure formed by nine coupled PCNCs. To carry out the control experiment, a trivial SSH structure is fabricated as well, which has ten coupled PCNCs, as shown in Figure 2c.

The fabricated devices are characterized by measuring their vertical light scattering using a cross-polarization microscope.\(^{[49]}\) A supercontinuum laser is employed as the broadband excitation light source, which is focused by an objective lens (50x, NA = 0.42) to a spot size of $\approx 2 \mu \text{m}$ over the cavity region. This ensures efficient in situ excitations and detections of the edge modes.\(^{[33,34]}\) The vertical scatterings of the resonance modes from the cavities are then collected by the same objective lens and finally analyzed by a spectrometer mounted with an InGaAs camera. To facilitate the study of position dependence of the edge mode, the devices are mounted on a 2D piezoactuated stage to realize their spatial movement with respect to the laser focusing point.

Figure 2d displays the measured scattering spectra from the single PCNC as it is spatially moved along the centerline in the $x$-axis, as indicated by the red dashed line in Figure 2a. Since the employed cross-polarization microscope only collects the scattering light with polarization perpendicular to the polarization of the incident laser, there should be no collected scattering signal over the photonic crystal lattice or unpatterned silicon slab. When the incident laser focuses on the cavity region, the light coupled into the cavity excites the resonance mode, whose far-field scattering has multiple polarization components. The scattering light from the resonance mode could therefore be collected and detected by the cross-polarization microscope. As a consequence, the position-dependent scattering spectra shown in Figure 2d represent resonance peaks when the incident laser is focused on the cavity region. These two resonance peaks are then verified from the mode simulations, as discussed below.

The position-dependent scattering spectra from the nontrivial SSH structure are acquired as well by moving it along the $x$-axis, as shown in Figure 2e. Though there are nine PCNCs, scattering peaks are only observed from the left terminal nanocavity $A_1$, matching well with the theoretical result in Figure 1c. The two scattering peaks have similar central wavelengths as those measured from the single PCNC shown in Figure 2d, i.e., the edge mode of SSH structure inherits the resonant property of its constitutive element. Different from the high signal-to-noise ratio of the resonant peak in the scattering spectra from the single PCNC, the scattering spectra from the nontrivial SSH structure have a broad background at the left side of the resonant peaks, as shown in Figure 2e.g. This could be attributed to the extra reflected background light of the incident supercontinuum laser from the adjacent L3 defects. This explanation could be verified from the results shown in Figure 2e,f obtained from the nontrivial and trivial SSH structures, respectively. When the incident laser is focused on the L3 defect regions, the scattering background light could be observed correspondingly from these locations, though there is no resonance mode over these defects. From the measured scattering spectra distribution of the single PCNC along the $x$-axis shown in Figure 2d, the spatial resolution of the measurement system along the $x$-axis is about $3.14 \mu \text{m}$, which is larger than the distances between the adjacent L3 defects (1.21 $\mu \text{m}$). As a result, when the incident light focuses on the nontrivial SSH structure in the cross-polarization microscope, part of the adjacent L3 defects within the detectable region will produce additional non-cross-polarization components and result in the scattering background around each site of nanocavities. In addition, because the employed supercontinuum laser source has weaker intensity at the longer wavelength, the scattering background on the right side of the resonant peak is not as obvious as that on the left side. In comparison, the position-dependent scattering spectra of the trivial SSH structure shown in Figure 2c are displayed in Figure 2f. There is only a similar scattering background but with no detectable resonant peak.

To study the resonance modes of the single PCNC and the non-trivial SSH structure in detail, in Figure 2g, we plot the scattering spectra from the interesting locations of the structures, which are indicated by the white dashed lines in Figure 2d,e. To assist the discussion, the two scattering peaks are successively marked as $M_j (M_j')$ and $M_i (M_i')$ from long to short wavelength for the single PCNC (the nontrivial SSH structure). In the device fabrication, for the single PCNC and nontrivial SSH structure, we repeat each of them by nine times in one process, which could facilitate the analysis of uncertainties. Except for those shown in Figure 2d,e, the scattering spectra from the other eight single PCNCs and the other eight nontrivial SSH structures are displayed by cyan plots in Figure 2g. Due to fabrication imperfections, certain deviations happen among the scattering spectra from different devices, which result in uncertainties of resonance wavelengths and $Q$ factors of resonance modes. Using Lorentzian fittings with two peaks around the two resonance modes, in the single PCNC, we obtain the $M_1$ mode locating at $1548.83 \pm 0.05 \text{ nm}$ with a $Q$ factor of $413 \pm 13$, and the $M_2$ mode locating at $1539.41 \pm 0.07 \text{ nm}$ with a $Q$ factor of $211 \pm 10$. On account of the background in the scattering spectrum in the nontrivial SSH structure, an extra polynomial curve is added to match the scattering background, as the gray shadow region shown in Figure 2g. In the nontriv-
Figure 2. a–c) SEM images of the a) single PCNC, b) nontrivial SSH structure, and c) trivial SSH structure. d–f) Measured position-dependent scattering spectra along their centerlines in the x-axis of the three structures shown in (a)–(c), respectively. g) Scattering spectra of the single PCNC and nontrivial SSH structure marked by the white dashed lines in (d) and (e), where two scattering peaks are successively marked as $M_1$ ($M_1'$) and $M_2$ ($M_2'$) for the single PCNC (nontrivial SSH structure). The blue lines are the Lorentzian fitting curves, the gray shadow region is the background fitted by an extra polynomial fitting curve, and the black and red lines are linear superpositions of the fitting curves. Scattering spectra of other devices with the same structure parameters are displayed by cyan plots. h, i) Simulated electric field distributions ($|E|^2$) of the two resonance modes in the h) single PCNC and i) nontrivial SSH structure. Scale bar: 1 μm.

The above experiment results are further verified by the mode simulations based on the finite element technique. Though there are only two resonance modes experimentally observed from the single PCNC, six resonance modes are obtained numerically, which is consistent with the previously reported results. According to the spacing between the resonance wavelengths as well as the polarization attributes of their far-field scatterings, the experimentally observed two peaks are recognized to have the electric field distributions ($|E|^2$) shown in Figure 2h. The other four resonance modes are not observed in the experiment, which could be attributed to their low coupling efficiencies in the cross-polarization microscope with the configuration of far-field coupling. From the simulation, the resonance wavelengths of $M_1$ and $M_2$ modes are 1538.91 nm and 1529.08 nm, and their $Q$ factors are 580 and 600, respectively. The derivations of the resonance wavelengths and $Q$ factors arise from the fabrication errors. Resonance modes of the nontrivial SSH structure with nine coupled PCNCs are then solved as well. Corresponding to the six resonance modes of the single PCNC, six topological edge modes are obtained from the SSH structure. For the experimentally observed two edge modes, which are formed by the couplings of $M_1$ mode and $M_2$ mode respectively, their electric field distributions ($|E|^2$) are displayed in Figure 2i. Strongly localized modes are observed only at the left terminal nanocavity $A_1$. The field profiles at $A_1$ are the same as their counterparts of the single PCNC.
During the simulation of two edge modes $M_1'$ and $M_2'$, according to electric field distributions with the specific distribution characters along the sites, nine eigenvalues in the nontrivial SSH structure are displayed in Figure 3a. Two edge modes $M_1'$ and $M_2'$ are located among their band gaps with a value of 15.42 and 99.18 nm, as indicated by the shadow areas in Figure 3a. Notice that different from eigenvalues distribution in Figure 1b, two edge modes are generally off the true center of the mode gap on account of the resonance wavelengths deviation of the nine PCNCs in the simulation. In addition, there is a wider band gap around the $M_2'$ mode, which could be attributed to the stronger field distribution of $M_2$ mode, as shown in Figure 2h. The stronger mode field confinement in an individual nanocavity will cause stronger coupling between two adjacent nanocavities separated by one row of air holes, then the resonance wavelengths of bulk modes will leave farther from that of the edge mode, and a wider band gap around the edge mode is finally formed. In the infinite SSH model, the mode gap is $2|\gamma_1 - \gamma_2|$. In the finite SSH model with nine sites, by diagonalizing the Hamiltonian in triple symmetric diagonal $9 \times 9$ matrix form in Equation (1), the mode gap is specifically equal to $2\sqrt{\gamma_1^2 + \gamma_2^2 - \frac{\gamma_1 \gamma_2}{\gamma_2 - \gamma_1}}$, which is slightly larger because of the looser confinement from the finite number sites to edge mode.

Apart from the almost same field profiles in the cavity regions of the single PCNC and the SSH structure, there exists exponentially decaying tail along sites in the SSH structure, which is closely related to the coupling strengths of the specific resonance modes. We integrate electromagnetic energy stored at each nanocavity site for modes $M_1'$ and $M_2'$, where the ratio $\gamma_2/\gamma_1$ is fitted from the exponential curve $\left(\frac{\gamma_2}{\gamma_1}\right)^{-N}$ along the hopping nanocavities $A_k$. Calculated $\gamma_1$ and $\gamma_2$ from their band gaps and ratios. Changes of the band gaps $\delta \Delta/\Delta$ around the edge modes $M_1'$ and $M_2'$ as a function of random coupling disorders based on the tight-binding model.

Figure 3. a) Simulated nine eigenvalues of the nontrivial SSH structure corresponding to resonance modes $M_1'$ and $M_2'$, where the shadow areas are the band gaps ($\Delta$) related to the coupling strengths. b) Electromagnetic energy ($\int \int \int |E|^2 dV$) stored at each nanocavity site for modes $M_1'$ and $M_2'$, where the ratio $\gamma_2/\gamma_1$ is fitted from the exponential curve $\left(\frac{\gamma_2}{\gamma_1}\right)^{-N}$ along the hopping nanocavities $A_k$. c) Calculated $\gamma_1$ and $\gamma_2$ from their band gaps and ratios. d) Changes of the band gaps $\delta \Delta/\Delta$ around the edge modes $M_1'$ and $M_2'$ as a function of random coupling disorders based on the tight-binding model.
strengths between the elements of the SSH model in the tight-binding model. The changes of band gaps ($\delta\Delta/\Delta$) are monitored to investigate the robustness of the obtained topological edge modes.\[^{[19]}\] The coupling strengths with disorders are formulated as $\gamma_i = \gamma \times (1 + \gamma \delta_i)$ ($i = 1, 2$), where $\delta_i$ ($0 \leq \delta_i \leq 1$) is the fluctuation factor that determines the overall degree of fluctuations and $\gamma$ is a random number within $-1$ and $1$. For each fluctuation factor $\delta_i$, one hundred random numbers $\gamma$s are taken, then one hundred corresponding band gaps around the edge mode are calculated. Finally, their changes of band gaps ($\delta\Delta/\Delta$) with errors are obtained. Figure 3d displays the change of band gaps ($\delta\Delta/\Delta$) of $M_1'$ and $M_1''$ modes as a function of random coupling disorders. As the disorder increases, both band gaps decrease monotonically with larger errors. Over the entire range of disorders, the changes of band gaps of two edge modes almost keep above $-100\%$, that is the band gaps remain open, which is consistent with the open band gap condition for topological edge modes. Compared with $M_1''$ mode, it is expected that $M_1'$ mode presents stronger robustness with the larger coupling strengths.

PCNC has been well considered as one of the optical resonators with the highest factor of $Q/V$, where $V$ is the mode volume. It therefore could be employed to realize strong light-matter interaction due to the strongly localized electric field of the resonance mode. A variety of nonlinear optical processes have been realized based on a single PCNC, such as second harmonic generation, THG, optical parametric oscillator, etc.\[^{[15,16]}\] Silicon, as a centrosymmetric material, has remarkable third-order nonlinearity. THG has been successfully reported in a silicon PCNC, which has potential applications to extend the light sources in silicon to visible spectral range.\[^{[14]}\] The above demonstrated results indicate the topological edge modes of the SSH structure composed by PCNCs could also support a strongly localized electric field, which interestingly has an extra attribute of robustness. It could therefore provide a platform to realize resonance enhanced silicon THG.

To carry out that, a pulsed laser (pulse width = 8.8 ps, and repetition rate = 18.5 MHz) with tunable wavelength is employed as the pump laser. The scattering THG signal from the structure is collected by the objective lens, which is then separated from the scattering pump laser by a short-pass filter and acquired using a visible spectrometer. By tuning the wavelength of the pump laser to match with the wavelength of the $M_1'$ mode ($\approx 1549.09$ nm), a strong signal peak is observed at one third of the THG wavelength ($\approx 516.36$ nm), as shown in Figure 4a. With a visible CMOS camera to image the SSH structure through the objective lens, an obvious green light spot is observed at the left terminal nanocavity $A_1$. To verify that the peak originates from the THG process, we examine its intensity dependence on the pump power, as shown in Figure 4b. As the pump power is increased gradually, the THG intensity varies in a cubic function. It shows a fitting line with a slope of $\approx 3.09$ in the log-log coordinate system, which is a typical character of the THG process. By fixing the wavelength and power of the pump laser, we also acquire the THG signals from the single PCNC and the trivial SSH structure displayed in Figure 2a,b. As shown in Figure 4c, benefiting from the localized $M_1$ mode in the single PCNC and $M_1'$ mode in the nontrivial SSH structure, they both appear strong THGs. On contrary, the THG in the trivial SSH structure is extremely weak due to the absent localized mode. Following the operation principle of the SSH structure, $M_1'$ mode in the nontrivial SSH structure naturally inherits resonant properties of $M_1$ mode in the single PCNC. Hence their THG intensities are almost identical, which both present three orders of magnitude enhancements (about 2460 times) compared with that in the trivial SSH structure. Note that the THGs realized in the single PCNC and nontrivial SSH structure exist essential differences in topology. The THG driven by the $M_1'$ mode in the nontrivial SSH structure possesses hereditary robustness from the topological edge mode, and could show a great potential on nonlinear topological photonics.

To confirm that the strongly enhanced THG benefits from the intense localized electric field of the topological edge mode, the dependence of the THG intensities from the SSH structure on the pump wavelength is examined, as plotted in Figure 4d. With a constant pump power, as the pump wavelength is turned away from the resonance wavelength, THG intensity decreases gradually to a mostly undetectable level. For a cavity resonance mode, the densities of optical power at different wavelengths are governed by a Lorentzian function ($f_{\text{Lorentz}}$), as indicated in Figure 2g. In the THG process, THG intensity typically varies as the cubic function of the pump power. Hence, the obtained THG intensities with respect to the pump wavelength should be established by the cubic function of $f_{\text{Lorentz}}$, as indicated by the fitting curve ($f_{\text{Lorentz}}$)$^3$ in Figure 4d. This clearly indicates that the achievement of strong THG relies on the edge mode.

The edge mode-enabled THG process is further illustrated by implementing its spatial mapping when the THG structure is spatially moved in the $x-y$ plane. Pumped with the on-resonance laser, the scattering THG signal and pump laser are simultaneously monitored using visible and near-infrared photodetectors, respectively. Figure 4e,f display the measured results. Only when the focusing spot of the pump laser overlaps with the location of the left terminal nanocavity $A_1$, the edge mode can be excited successfully. This matches well with the simulation result shown in Figure 2i. Because the THG process is a cubic function of the pump light, and it is pumped by the near-field of the resonance edge mode, the spatial area of the THG is much smaller than that of the edge mode. To clarify this, in Figure 4g, we plot the spatial profiles of the THG (red dots) and edge mode (black dots) along the white dashed lines in Figure 4e,f. The enhanced THG mainly focuses on the left terminal nanocavity $A_1$ within the strongest field distribution, and its half-height width of the spatial distribution along the $x$-axis is reduced by 0.71 $\mu$m. In addition, the exponentially decaying tail of edge mode along the chain is restrained by about 10 dB in the THG.

4. Conclusion

In conclusion, we have experimentally observed a strongly enhanced THG process in a silicon SSH structure consisting of coupled PCNCs, which is enabled by the localized electric field of the topological edge mode. The edge mode of the SSH structure not only naturally inherits resonant properties of a single PCNC, but also manifests topological feature with steady robustness extending well beyond an individual cavity. From the fabricated nontrivial SSH structure, a strong THG signal similar to that obtained from a single nanocavity is obtained, which both show three orders of magnitude enhancement compared with that in a trivial SSH structure. Compared with the spatial distribution of the
edge mode, the THG exhibits suppression of the decaying tail of the edge mode due to the cubic relationship between its intensity and that of the edge mode. Our results indicate that the SSH structure of PCNCs could provide a promising platform for topology-driven nonlinear processes in device development such as robust visible emitters and entangled photon pairs on silicon chips.

Acknowledgements

The financial support for this work was provided by the Key Research and Development Program (Grant No. 2017YFA0303800), the National Natural Science Foundation (Grant Nos. 91950119, 11634010, 61775183, and 61905196), the Key Research and Development Program in Shaanxi Province of China (2020Z-10), the Fundamental Research Funds for the Central Universities (310201911cx032 and 3102019JC008), and the Doctorate Foundation of Northwestern Polytechnical University (CX201924).

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflict of Interest

The authors declare no conflict of interest.

Keywords

photonic crystal nanocavities, Su-Schrieffer-Heeger model, third harmonic generation, topological photonics
