Cavity-Enhanced Symmetric Second-Harmonic Generation

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Symmetric second-harmonic generation (SSHG) achieved through backward quasi-phase-matching (BQPM) [1] has distinctive characteristics compared with conventional forward second-harmonic generation, where the fundamental and second-harmonic waves co-propagate. In SSHG, the poling period of the nonlinear crystal must satisfy: $\Lambda = 2\pi m/k_{2\omega}$ (which differs from the polarization period requirement for FSHG $\Lambda = 2\pi m/\left|2k_{\omega} - k_{2\omega}\right|$), where m is the order of QPM, while k_{ω} and $k_{2\omega}$ are the wave vectors of the fundamental and second-harmonic waves, respectively. The BQPM condition causes it to have a narrower wavelength tuning bandwidth. SSHG involves six different phase-matched processes (in contrast to the two processes in FSHG). At a finite pump intensity, the conversion efficiency can reach its maximum value (which differs from FSHG where the conversion efficiency asymptotically approaches complete conversion at an infinite pump intensity), and below a certain pump intensity, the conversion efficiency is higher than that based on FSHG. SSHG also has potential applications in all-optical switching and modulation.

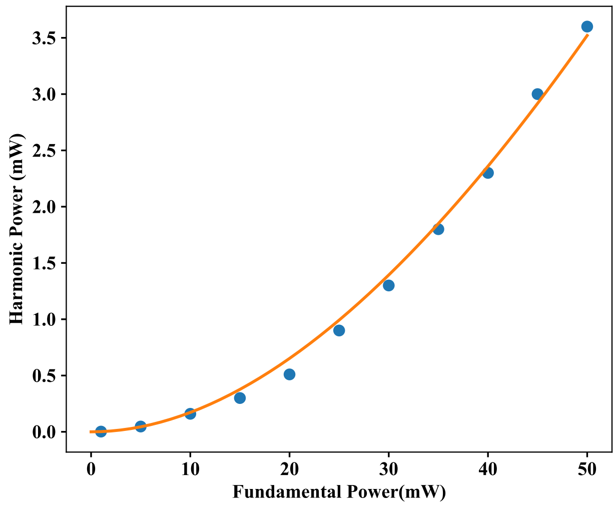

Figure 1: One-side second-harmonic power as a function of the fundamental power. The dots represent the experimental data and the curve shows the results of the simulation

However, first-order SSHG necessitates a submicron poling period, which imposes stringent requirements on the poling process.The implementation of higher-order QPM relaxes the requirements for poling periods while introducing the issue of reduced conversion efficiency [2]. A prevalent strategy for efficiency enhancement involves the utilization of a periodically poled crystal waveguide or a cavity. SSHG in waveguides has already been experimentally demonstrated [3]. There have been no reports to date on enhancing the efficiency of SSHG using a cavity.

In this work, we demonstrate that the conversion efficiency of higher-order SSHG can be significantly enhanced by employing a semi-monolithic cavity. With a fundamental power of 50 mW, a second-harmonic one-sided output of 3.6 mW was obtained, corresponding to a conversion efficiency of 7.2% (figure 1). Taking into account the equivalent second-harmonic output from the other side, the total efficiency reaches 14.4%. This demonstration significantly advances the application potential of SSHG and BQPM in nonlinear and quantum optics.

References

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