sample. Their periods should fit the requirement for EO polarization for signal or idlers waves. Separate voltage should be applied only to the corresponding sections. In principle, arbitrary polarization state could be generated.

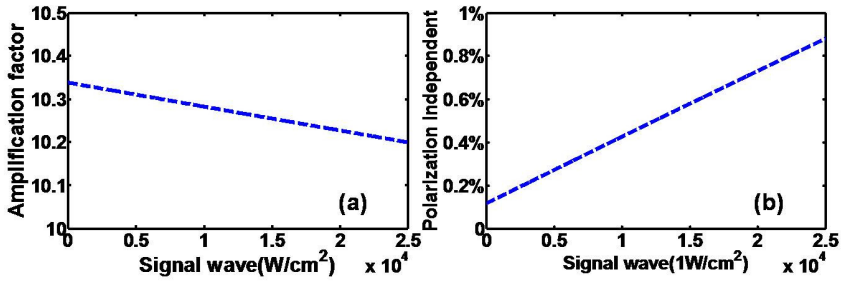

Fig. 4. (a) The PPLN OPA's amplification factor at different signal wave intensities. (b) Polarization induced amplification fluctuation as a function of the signal wave intensity.

Along with the 810 nm signal wave, an idler wave at 1550 nm telecom band is also generated. Actually we may also take the 1550 nm light as the signal for amplification. In this case, some fiber-optic applications may be expected. Actually other signal, idler wavelengths and amplification factor also could be achieved as long as we redesign the PPLN or change the pump wave. If the basic four-section structure is kept with EO rotation in the two central sections, polarization independent OPA still could be realized for arbitrarily polarized signal waves. From our analysis, our OPA even may work for vector beams [12] with complicated wavefront. For example, given a radially polarized signal light, we may treat the whole light as many beams with different polarization states. When they enter our sample, all these beams could be amplified with the same magnification ratio no matter what their polarization states are. After the beams pass through the sample, the light power is greatly enhanced while still keeping the vector beams characteristics. As we know, generating vector beams is normally not easy. Due to the limitation of used approach, it is not convenient to obtain the beams in some wavelength band, *i.e.*, infrared region. Furthermore, most of the crystal based active amplification or OPA are sensitive to polarization states, which makes it difficult to amplify vector beams. However, our multi-section PPLN based OPA might open a new window to obtain high power vector beams in new wavelength bands. In addition, our design takes the advantages of PPLN's EO and nonlinear optical properties together. The whole device is controlled by electric field, which means it may also work like an EO modulator for a given input signal. There are really many topics to study in this system. More interesting technical applications are anticipated.

4. Conclusion

In conclusion, we propose a way to amplify arbitrarily polarized wave using a four-section PPLN sample. A DC electric field is applied on selected sections. No matter what polarized direction the signal wave has, it may be effectively amplified with negligible polarization dependency. And, the OPA remains good performance over a wide range of input signal intensities. The accompanying idler wave, producing due to OPA process, can be used in communication and so on. Not only our design can be used in amplifying waves from fibers such as vector beams, but also it is practical in many other fields like EO modulator.

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