$In_xGa_{1-x}As_yP_{1-y}$ on Insulator Waveguide Design for Second Order Nonlinear Optical Processes

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III-V semiconductors offer a unique approach to applications in photonics for incorporating light sources into photonic circuits to minimize loss. Many common approaches for developing photonic circuits are based on silicon, which offers complementary metal–oxide–semiconductor (CMOS) compatibility, allowing for incorporation into existing foundry processes [1]. However, Silicon lacks the material properties necessary for lasing, and second order nonlinear optical processes [2]. Quaternary III-V semiconductor material platforms such as $In_xGa_{1-x}As_yP_{1-y}$ offers the advantage of being a direct bandgap material, with a non-zero $\chi^{(2)}$ parameter, allowing for integration of low loss light sources, as well as nonlinear optical processes [3]. The work presented will cover simulations of viable design geometries for an $In_xGa_{1-x}As_yP_{1-y}$ on Insulator waveguide, with low group velocity dispersion at a wavelength of 1550 nm as well as theoretical second harmonic generation conversion efficiency calculations for a fundamental wavelength of 2620 nm. The results of the simulations completed so far indicate that a waveguide geometry of 400 x 580 nm has an approximate group velocity dispersion value of 0.4 ps/nm Km at 1550 nm. Also, a 2100 x 200 nm geometry meets the necessary type-I phase matching and mode overlap conditions for second harmonic generation. Calculations indicate a theoretical conversion efficiency of approximately 50% at a fundamental wavelength of 2620 nm, while ignoring loss and pump depletion. From the current progress, numerical results indicate that there exists $In_xGa_{1-x}As_yP_{1-y}$ on Insulator waveguide geometries which can be beneficial in nonlinear optical processes essential in quantum communication and sensing applications.

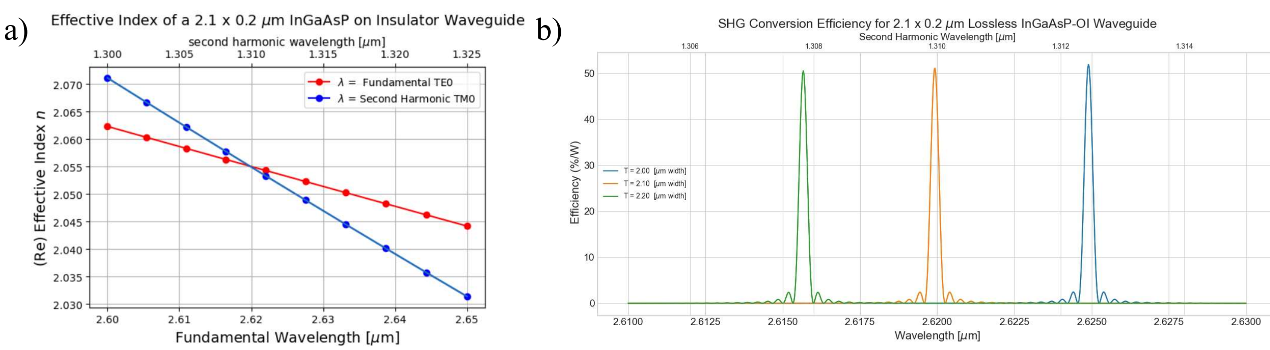

Fig.1.a) Effective index of the TE0 polarization of the fundamental wavelength, and TM0 polarization of the second harmonic for an $In_xGa_{1-x}As_yP_{1-y}$ on Insulator waveguide, phase matching is indicated as the point where the two effective indices are equal at approximately 2.62 μm wavelength. b) Theoretical second harmonic generation efficiency (%/W) of a 2.0x0.2, 2.1x0.2, and 2.2x0.2 μm, 1 mm length $In_xGa_{1-x}As_yP_{1-y}$ on insulator waveguide assuming a lossless waveguide with no pump depletion.

References

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