Second-harmonic generation in periodically poled silicon waveguides with lateral p-i-n junctions

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Nemo

SPIE. STUDENT CHAPTER

Abstract The aim of this work is to generate a second harmonic signal in silicon waveguides. We used the Electric Field Induced Second Harmonic Generation effect to overcome the silicon centrosymmetricity. In this work we present a new poling configuration able to increase the SHG efficiency by about one order of magnitude.

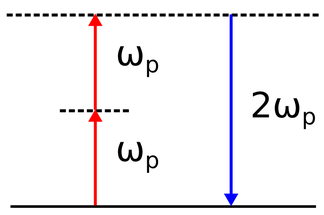
Nonlinear Optics

Dielectric polarization density:

$$P(t)=\varepsilon_0\left(\chi^{(1)}E(t)+\chi^{(2)}E^2(t)+\chi^{(3)}E^3(t)+\dots\right)$$

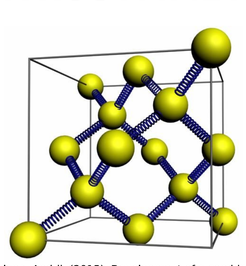
Linear optical effects | **Second Order Nonlinear effects** | **Third Order Nonlinear effects**

Second Harmonic Generation



Issue

Silicon is CENTROSYMMETRIC



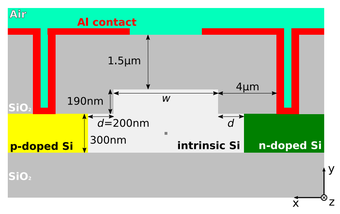
Prylepa, Andrii. (2015). Development of a combined rotation anisotropy SHG, laser scanning and interferometric SHG microscopy system for material investigations.

$\Rightarrow$ **No $\chi^{(2)}$**

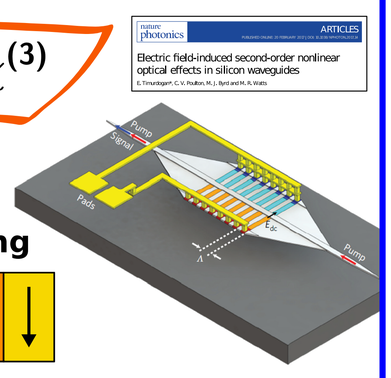
Solution: Electric Field Induced Second Harmonic Generation (EFISHG)

Lateral p-i-n junction

Cross Section



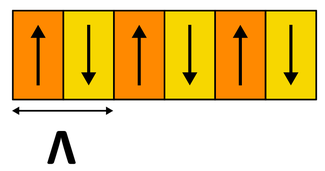
$$\chi^{(2)}_{eff}=3E_{DC}\chi^{(3)}$$



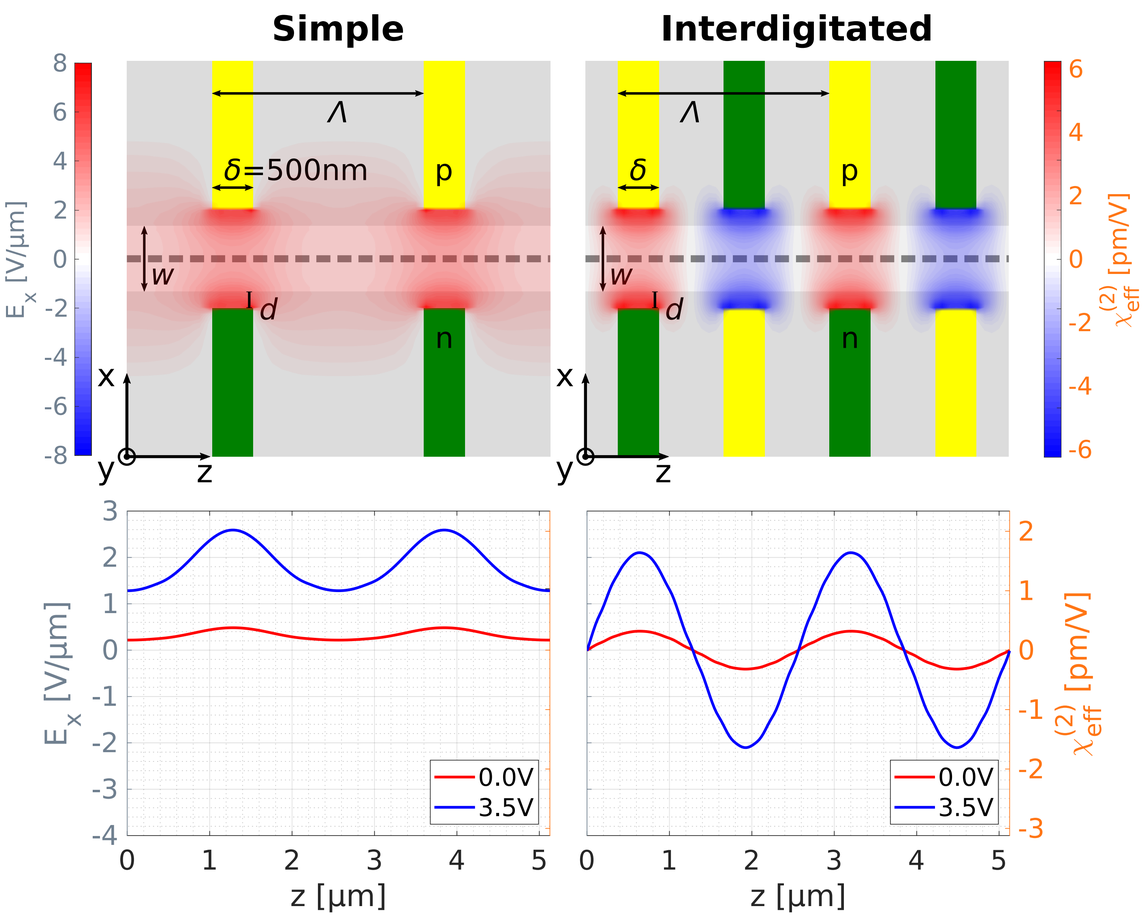
Quasi phase matching

$$2k_p-k_{sh}+\frac{2\pi}{\Lambda}=0$$

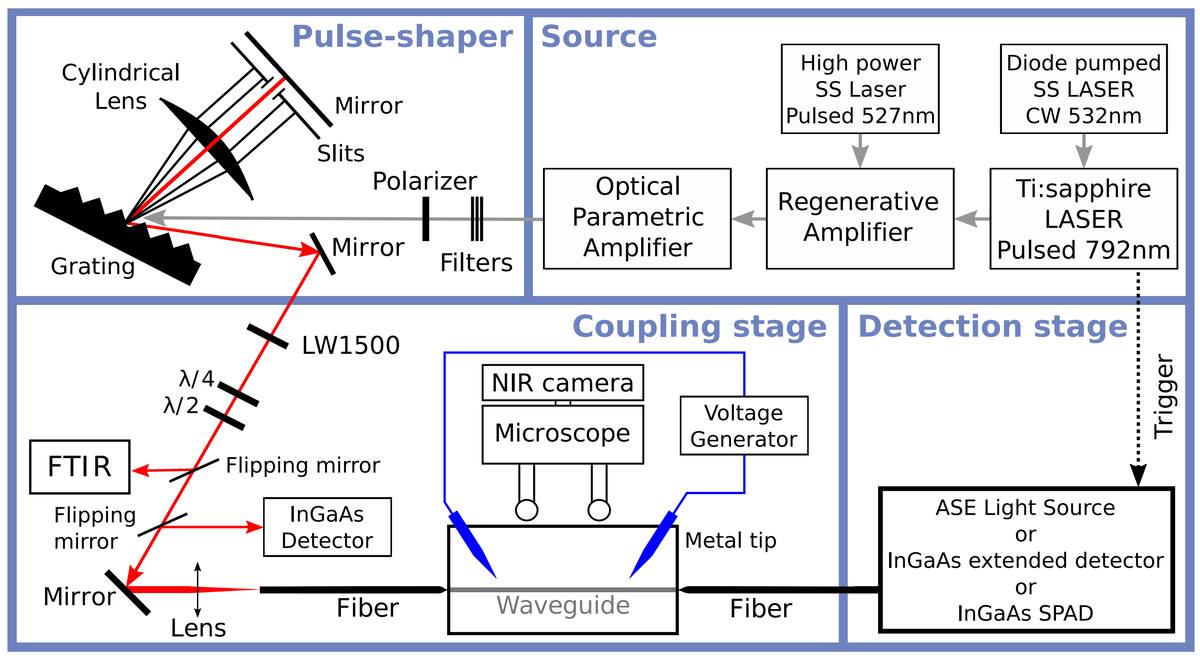
Periodic Poling



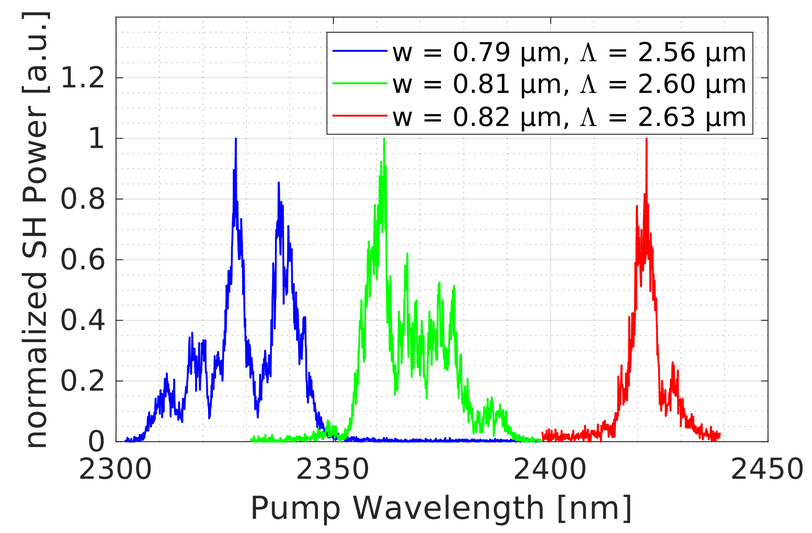
Poling Configuration

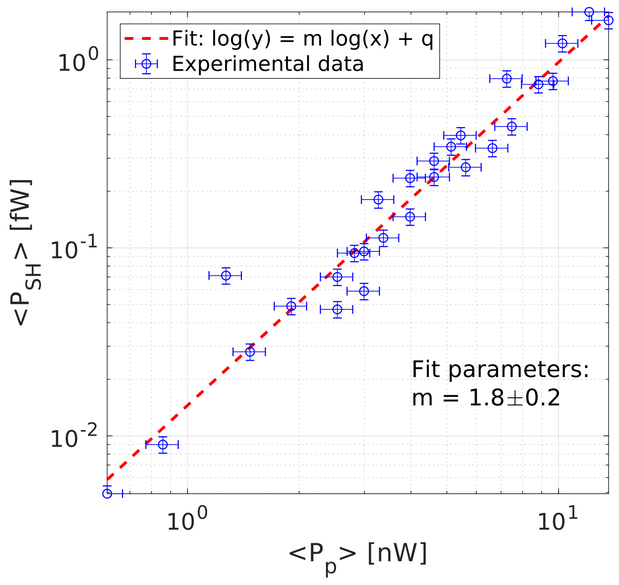


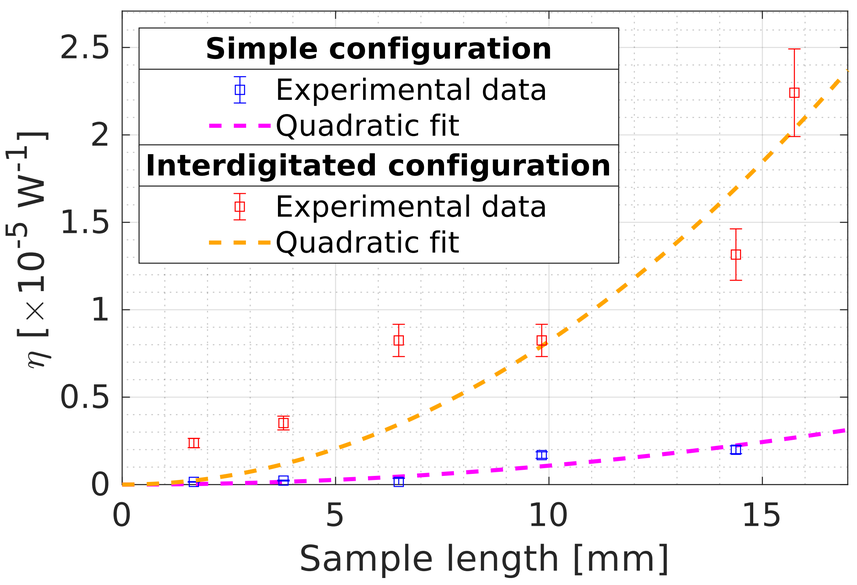
Experimental Setup

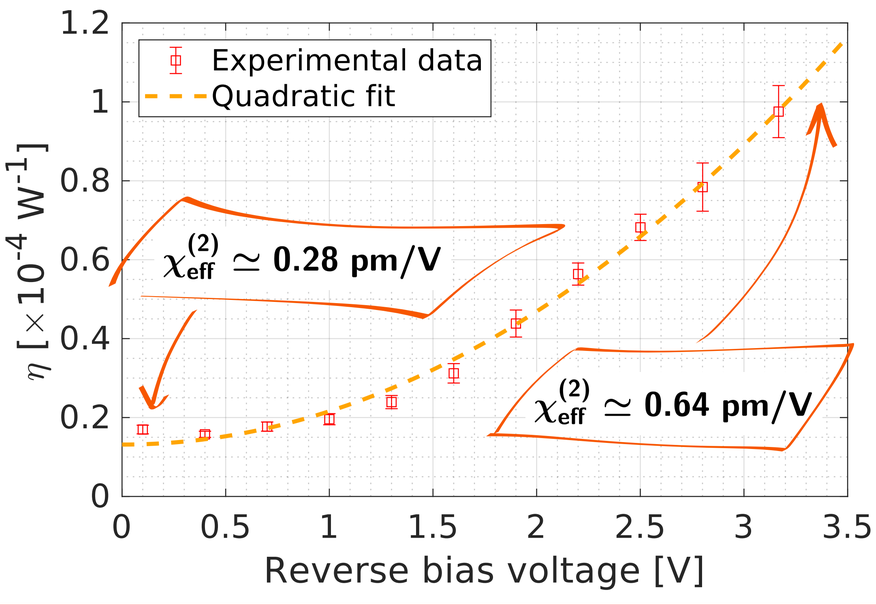


$$P_{sh}\propto P_p^2\left|\chi^{(2)}_{eff}\right|^2L^2 \quad\Rightarrow\quad \eta:=\frac{P_{sh}}{P_p^2}\propto\left|\chi^{(2)}_{eff}\right|^2L^2$$









Perspectives

- Difference Frequency Generation (**DFG**)
- Spontaneous Parametric Down Conversion (**SPDC**) to generate **entangled** photon pairs in MIR
- Mid-Infrared (MIR) **quantum sensing**

DFG / SPDC