Nonlinear Optical Engineering

Nonlinear Susceptibility (1)

Yoonchan Jeong

School of Electrical Engineering, Seoul National University

Tel: +82 (0)2 880 1623, Fax: +82 (0)2 873 9953

Email: yoonchan@snu.ac.kr

Nonlinear Polarisation

Constitutive relations:

$$\mathbf{D} = \varepsilon\mathbf{E} = \varepsilon_o\mathbf{E} + \mathbf{P},$$

$$\mathbf{P} = \varepsilon_o\chi\mathbf{E}$$

Origin of the nonlinear response:

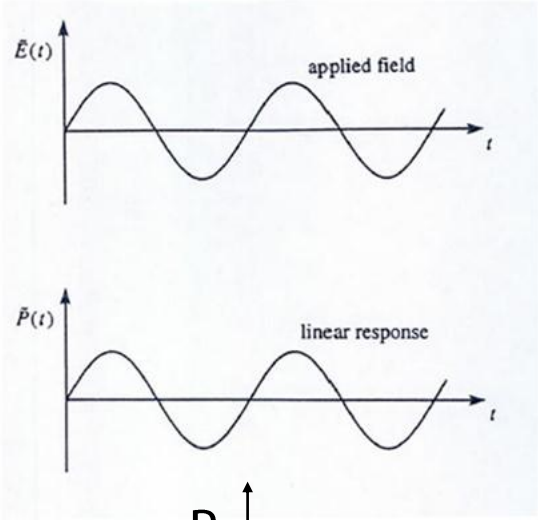
$$\mathbf{P} = \varepsilon_o\chi\mathbf{E} = \varepsilon_o\left(\chi^{(1)}\mathbf{E} + \chi^{(2)}\mathbf{EE} + \chi^{(3)}\mathbf{EEE} + \cdots\right)$$

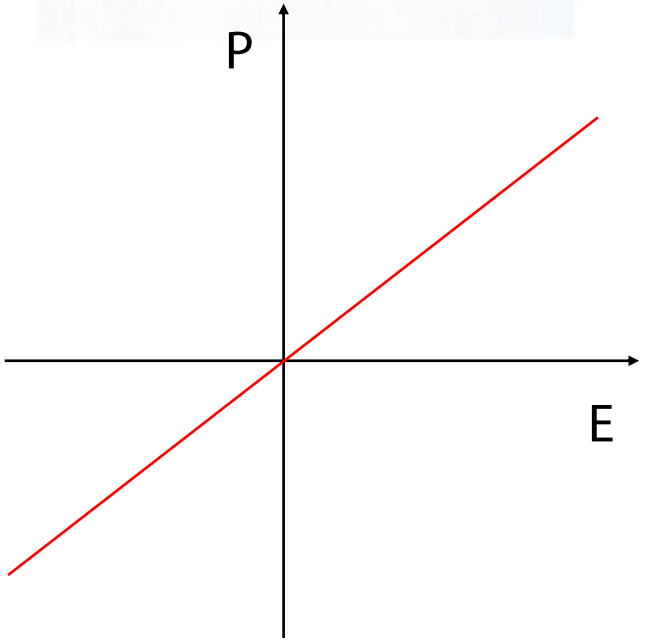
← Anharmonic motion of bound electrons

Note: Non-zero $\chi^{(2)}$ only for media that lack an inversion symmetry (centrosymmetry)

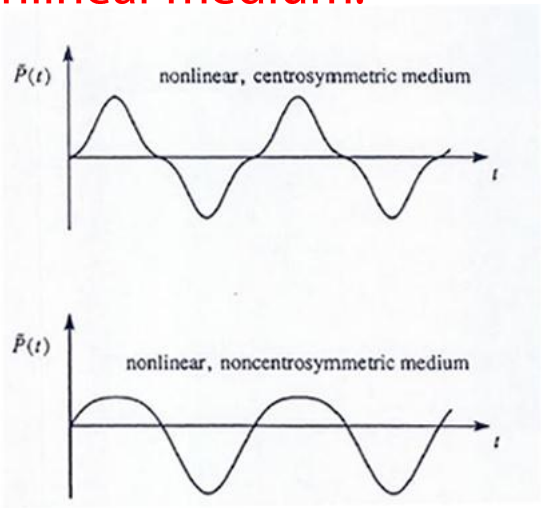
Linear and Nonlinear Atomic Response

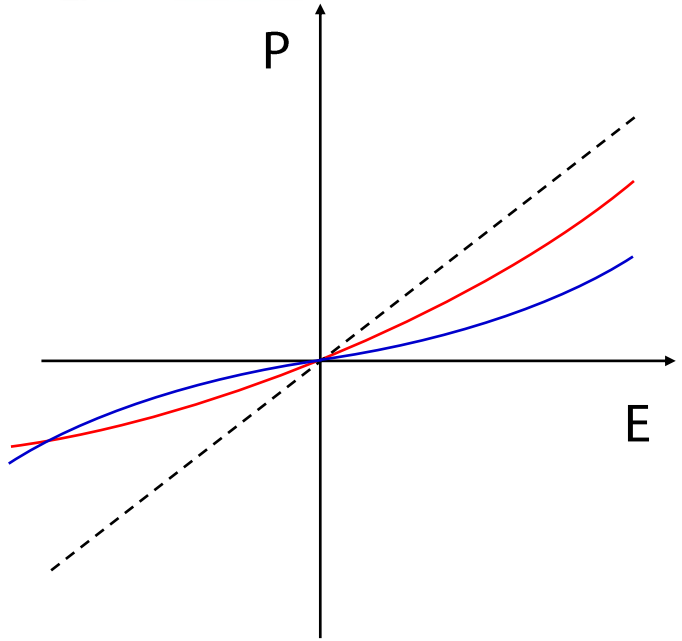
Linear medium:





Nonlinear medium:

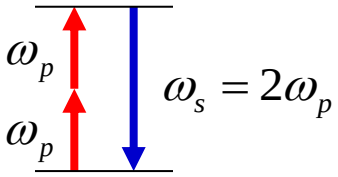




Nonlinear Interactions

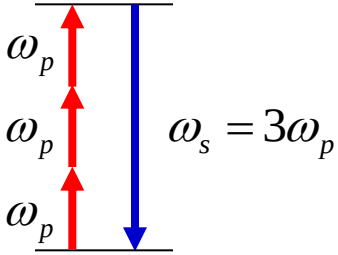
Second-order nonlinear interaction:

Linear (or Pockels) electro-optic effect
Second-harmonic generation
Sum frequency generation



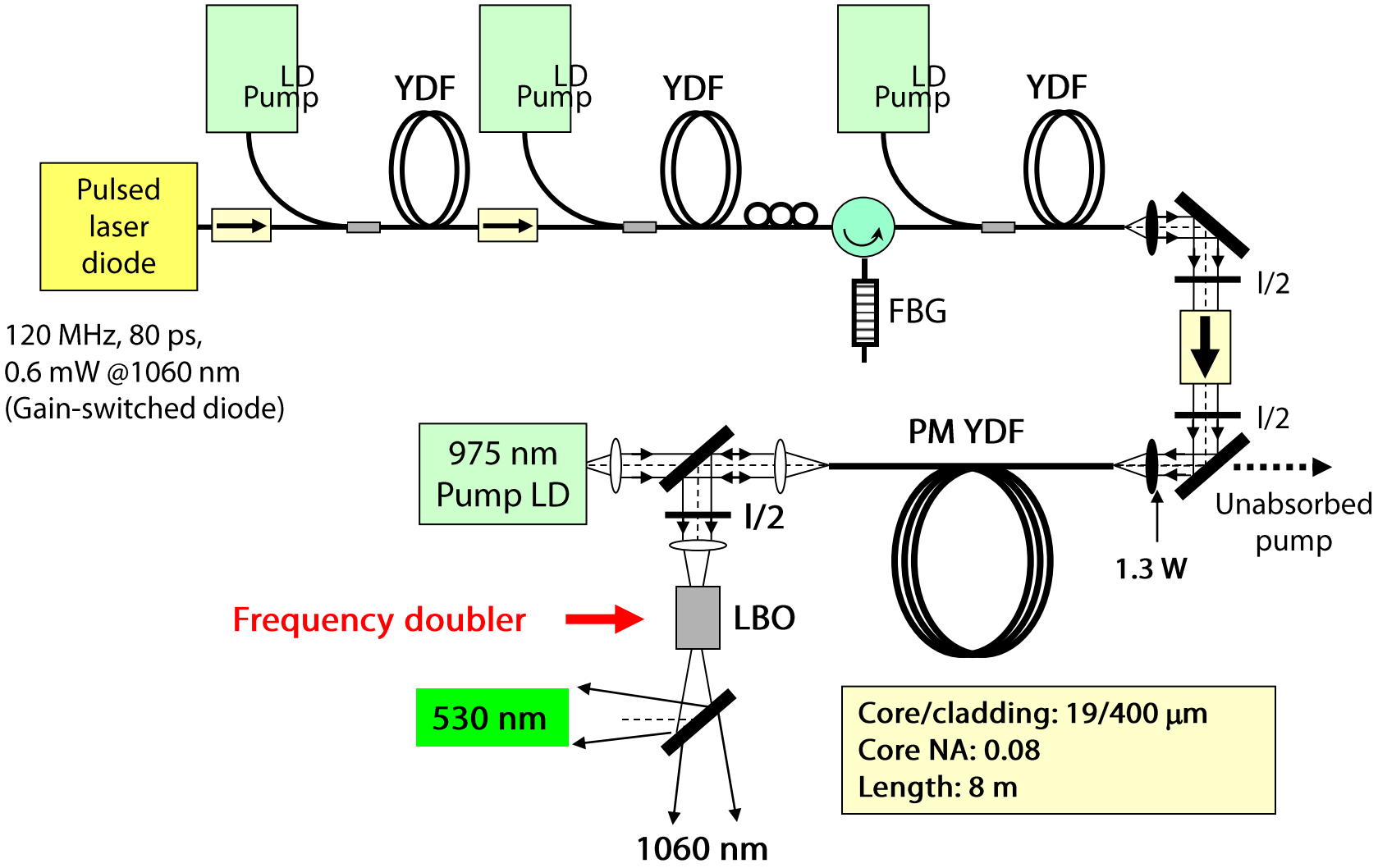
Third-order nonlinear interaction:

Quadratic (or Kerr) electro-optic effect
Third-harmonic generation
Four-wave mixing
Self-phase modulation
Cross-phase modulation
Self focusing

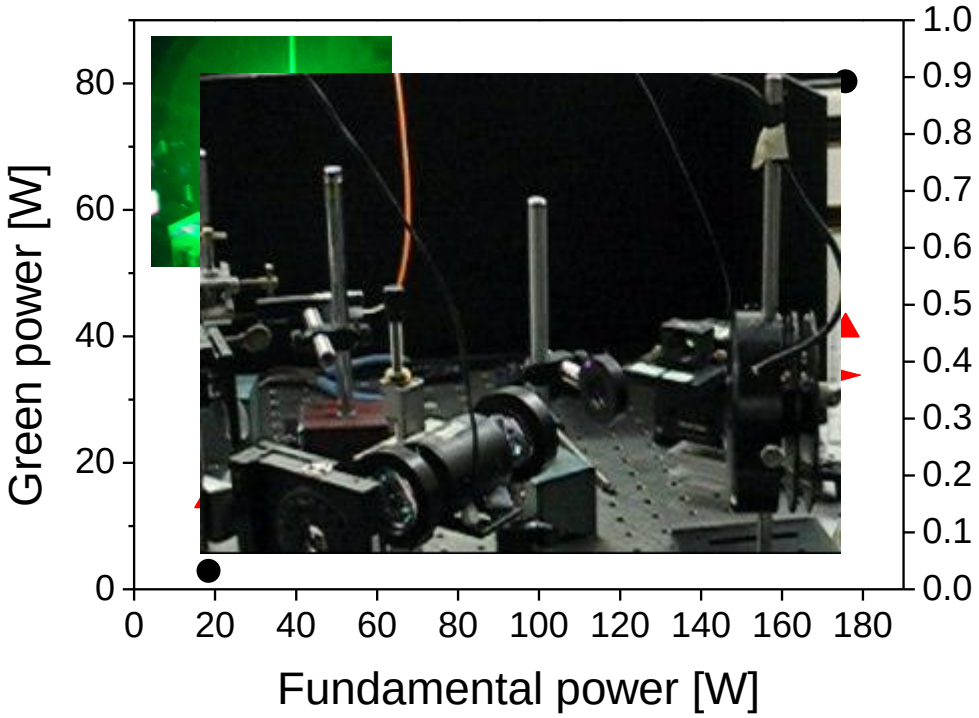


SHG Based on a Fiber MOPA at 1060 nm

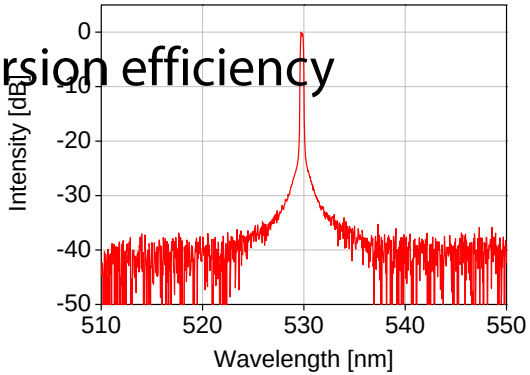
Experimental arrangement:

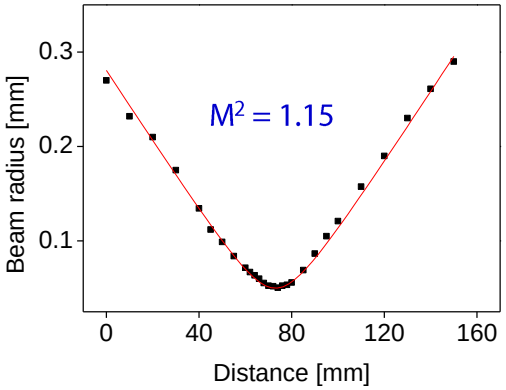


Frequency-Doubled Output at 530 nm



Conversion efficiency



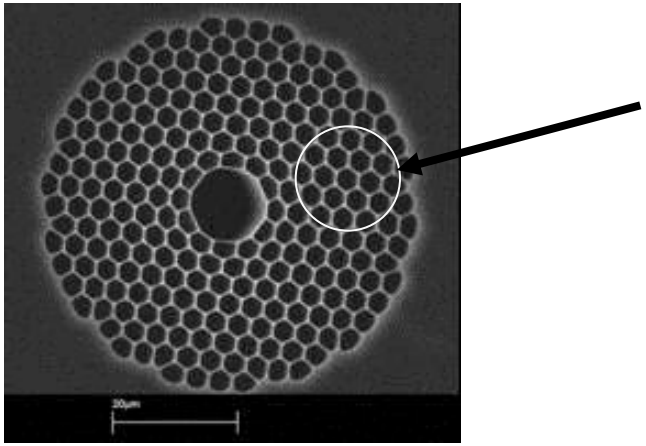


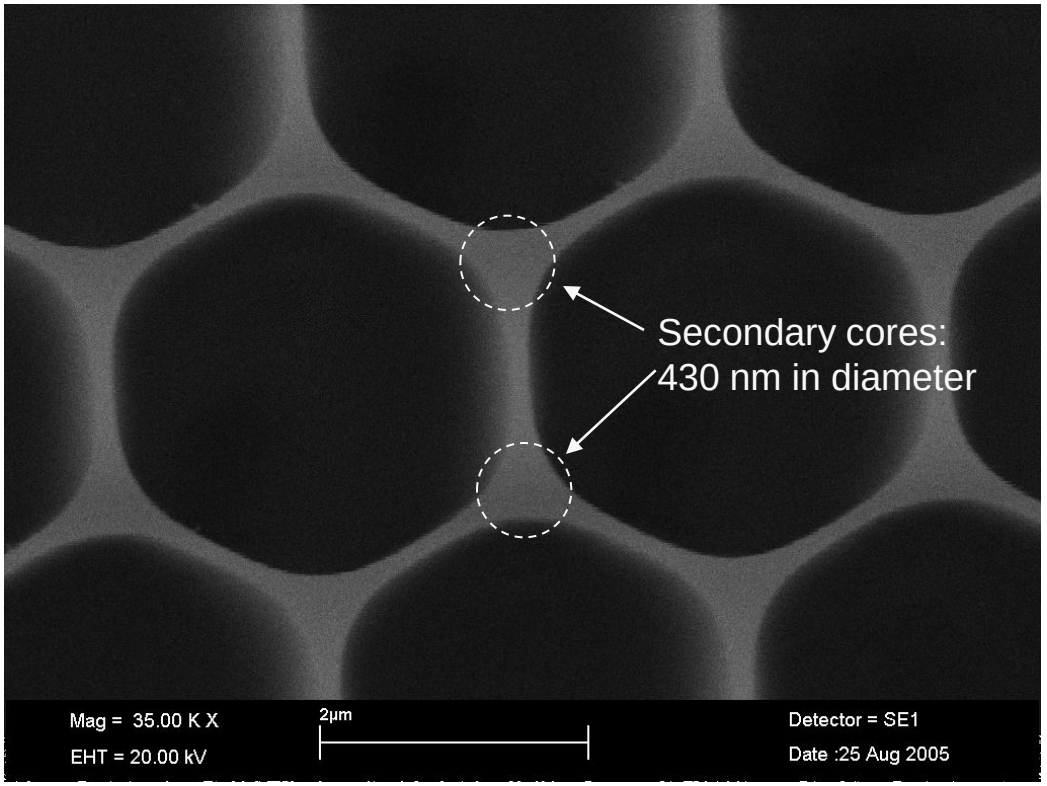
- Maximum output power at 530 nm: 80 W
- Conversion efficiency: 46%
- Nearly diffraction limited beam: $M^2 = 1.15$

Four-Wave-Mixing in an Optical Fiber

Fiber Parameters:

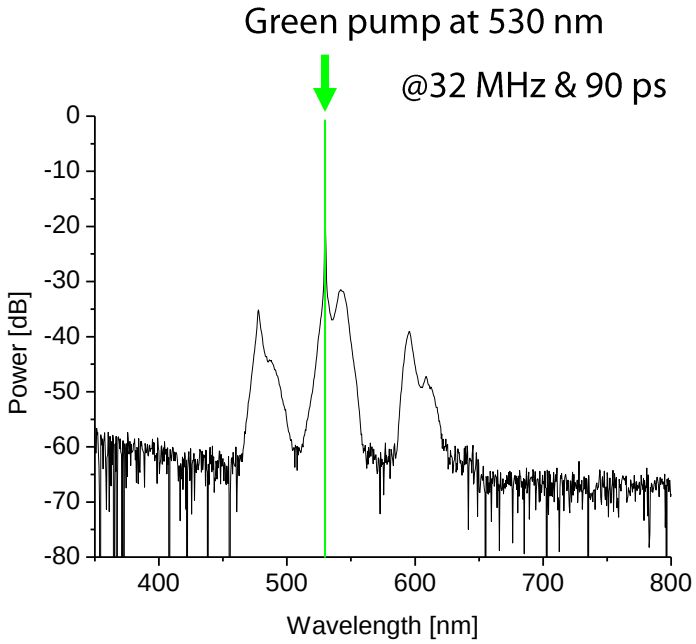
Structure: 7-point core defect, 7½ ring structure.
Hole-to-hole spacing: 3.6 μm
Hole diameter relative size (d/Λ): 0.95
Air filling factor: ~87%
Core diameter: 11.6 μm.
Fundamental bandgap: 1570 nm.
Higher order: 458, 505, 560 nm
(Fabricated from the resources outside the project)

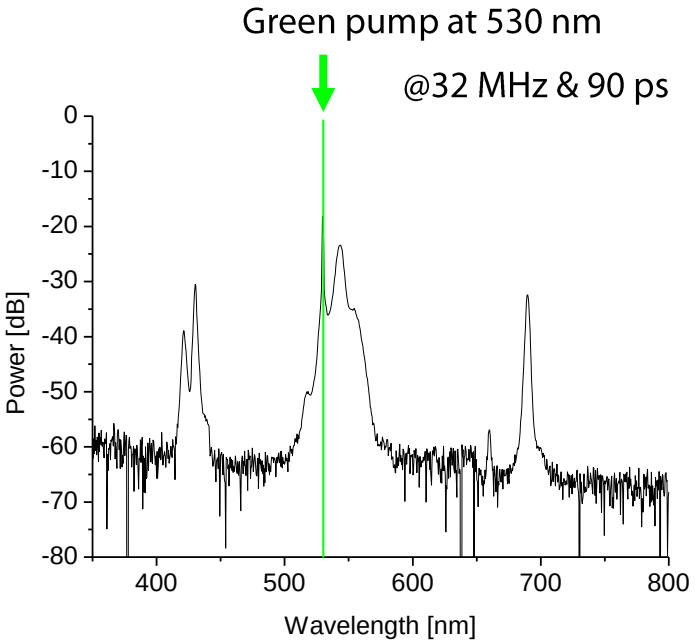




Secondary cores to be investigated for four-wave mixing!

RGB Generation via FWM in an Optical Fiber





Diffracted output image