

Quizzes and short questions QUANTUM ELECTRONICS
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Module 3: Quizzes and short questions

1. Q: The phase matched SHG efficiency of a 5 cm long crystal is 1%. For what value of Δk will the efficiency become zero?
2. Q: It is given that phase matching is possible in a crystal with $n_o > n_e$ for SHG for wave propagation along the x -axis of the crystal. What polarization would you choose for ω and what will be the corresponding polarization for the generated 2ω ?
3. Q: Consider SHG in lithium niobate. An ordinary wave at a wavelength of 1000 nm gets converted to an e-wave at 500 nm. Obtain the QPM period required for efficient SHG. Given $n_o(\omega) = 2.236$, $n_e(\omega) = 2.160$, $n_o(2\omega) = 2.341$ and $n_e(2\omega) = 2.249$.
4. Q: Input light at 1200 nm having a power of 0.1 mW interacts with 1 W of light at 800 nm and gets amplified to 0.2 mW at the exit of the crystal. Obtain the power exiting at the wavelength of 800 nm.
5. Q: I wish to achieve parametric amplification with signal at 1200 nm and pump at 800 nm travelling along the same direction and the idler travelling in the reverse direction. If the refractive indices at pump, signal and idler are 2.17, 2.15 and 2.11 respectively, calculate the period required for first order QPM.
6. Q: Consider sum frequency generation with 1 W of power at 1000 nm and 1 mW of power at 1500 nm. What is the maximum power achievable at the sum frequency?

Answers of module 3 Quizzes and short questions:

A1: The efficiency of SHG depends on phase mismatch through the following:

$$\eta \sim \frac{\sin^2\left(\frac{\Delta k L}{2}\right)}{\left(\frac{\Delta k L}{2}\right)^2}$$

Hence the efficiency for SHG will become zero when $\Delta k = 2\pi/L$ which for the values given gives us $\Delta k = 1.26 \text{ cm}^{-1}$.

A2: Dispersion implies that the refractive index will increase with increase in frequency. Since $n_o > n_e$ we should choose the fundamental to be an ordinary wave and the exiting second harmonic will be an extraordinary wave.

A 3: The spatial frequency required for QPM is given by the following equation:

$$K = 2k_o(\omega) - k_e(2\omega)$$

From which we obtain the required period as $\sim 38.5 \text{ }\mu\text{m}$.

A4: This process corresponds to parametric amplification with the idler being at the wavelength given by

$$\lambda_i = \left(\frac{1}{\lambda_p} - \frac{1}{\lambda_s}\right)^{-1}$$

which gives us $\lambda_i = 2400 \text{ nm}$. The signal power at 1200 nm has increased by $\Delta P_s = 0.1 \text{ mW}$ which corresponds to an increase in photon numbers of $\Delta N_s = \Delta P_s / \hbar\omega_s$. The number of idler photons generated must be equal to this value. Thus the power exiting at the idler wavelength would be $P_i = \Delta N_s \hbar\omega_i = 0.05 \text{ mW}$. Thus the total power lost by the pump is 0.15 mW and hence the power exiting at the pump wavelength would be 999.85 mW .

A5: The quasi phase matching condition is given by

$$\frac{1}{\Lambda} = \frac{n_p}{\lambda_p} - \frac{n_s}{\lambda_s} + \frac{n_i}{\lambda_i}$$

which gives us $\Lambda \sim 1.1 \text{ }\mu\text{m}$.

A6: The sum frequency corresponds to a wavelength of $\lambda_p = 600 \text{ nm}$. Maximum power would correspond to the situation when all the power at 1500 nm gets converted to the sum frequency. Thus the maximum power at the sum frequency would be given by

$$P_p = \frac{P_i}{\hbar\omega_i} \hbar\omega_p = 2.5 \text{ mW}$$