國 立 清 華 大 學 命 題 紙

一零三 學年度第二學期 光電工程研究所 博士班研究生資格考試

科目 光電子學二 科號 ____ 共 2 頁第 1 頁 *請在試卷(答案卷)內作答

1. (10%) (a) Assume an optical waveguide is single-mode at 1550 nm. If we use this waveguide for a green laser, is this waveguide more possible to be single-mode or become multi-mode? Please explain. (5%) (Answer without explanation won't count.) (b) Explain why dielectric waveguides cannot support TEM waves. (5%)
2. (10%) In optical fiber communication systems, if we can generate a narrower signal pulse from an optical light source, then, in one second, we can send more signal pulses, which means more data, into optical fiber. However, due to the existing chromatic dispersion in optical fibers, the transmission distance of such short pulses is limited. Starting from the physical effect and definition of chromatic dispersion, please explain why the transmission distance of the optical ultra-short pulses will be limited in optical fibers.
3. (10%) Consider the polarization response of the bound electron cloud as a spring modeled with a damped harmonic oscillator, then, show that for a harmonic wave with the frequency, ω, the corresponding spectrum for the atomic polarization can be obtained with a Lorentzian profile.
4. (10%) (a) A commercially available ruby laser amplifier using a 15-cm-long rod has a small-signal gain of 12. What is the small-signal gain of a 20-cm-long rod? Neglect gain saturation effects. (5%) (b) What is saturation optical intensity and how to do the estimation? (5%)
5. (10 %) Gain switching and Q-switching are two common techniques for generating short laser pulses.
   (a) To describe and compare the mechanisms of these two techniques, please carefully draw the **detailed** evolutions of the pump, the loss, the gain (population difference), and the photon number density for at least an entire cycle in time. Please mark and show all the critical timings clearly (ie. starting of the pulse, peak of the pulse, peak of the gain, and relations between the pump, loss, gain, and photon density, etc.). (6%)
   (b) What are the conditions and requirements to get the shortest pulse from these techniques? (2%)
   (c) Ideally, what are the shortest pulsewidths possible for these techniques? (2%)
6. (10%) Suppose a semiconductor with a material bandgap of 0.8 eV. Please answer the following questions
   (a) What is the longest emission wavelength? (5%)
   (b) If this semiconductor is utilized to make a diode laser, what is the minimum bias voltage? (5%)

7. (10%) (a) Why could a forward-biased pn-junction act as a light-emitting diode (LED) or a semiconductor laser gain medium? (5%) (Hint: Plot the corresponding energy band diagram.) (b) What are the minimum and maximum frequencies and that can be amplified by a semiconductor gain medium? (5%)

8. (10%) Please explain why the Pockels effect doesn't exist in a centrosymmetric material?

9. (10%) In second-harmonic generations, discuss the importance of phase mismatch.

10. (10%) The following is a photograph of laser wavelength conversion, showing a Q-switched Nd:YAG laser at 1064 nm (inviable to human eyes) on the left pumping a quasi-phase-matched nonlinear optical material, called periodically poled lithium niobate. A beautiful rainbow-like output is generated to the right of the photograph. Detail all the possible processes happening in the nonlinear crystal and estimate the wavelengths of the blue, green, yellow, and red colors observed in the output, if you also measure a strong infrared output at 1560 nm.