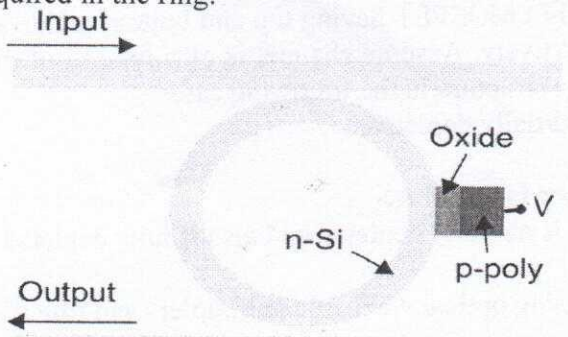
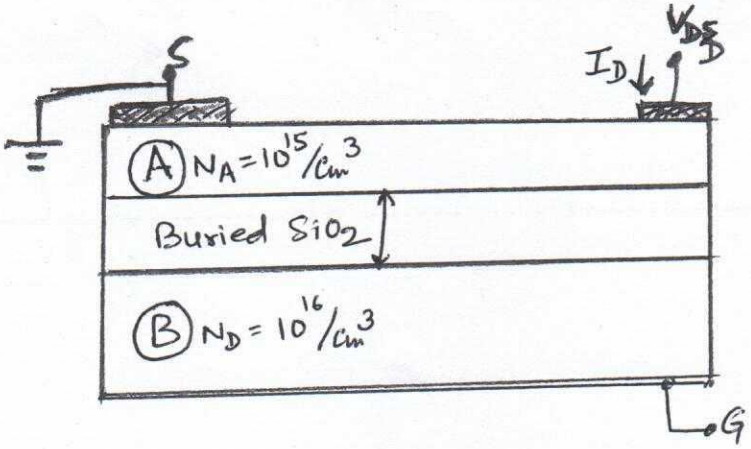
BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI, RAJASTHAN
First Semester 2023-2024
Comprehensive Examination

Course no: EEE G595 — Max. Marks :70
Course Title: Nano electr. & nano photonics Tech. **(Open-Book- 35 marks)** — Weightage : 35%
Date : 08-12-2023 (90 minutes) — Duration : 3Hrs

Q.1 (a) A ring resonator can couple wavelengths entering from input to output. Assume all waveguides are having index as 3.5 and two wavelengths 1520 and 1540 nm are entering through input planar wave guide. Estimate the radius of the ring to start coupling a given wavelength from input to output without any voltage on p-poly. Now if a voltage V1 is applied to shift the coupling wavelength to the other one , then predict the change in effective index required in the ring.



(b) : Sketch and label the I_D Vs V_{DS} curve for the case V_G is biased positive and also negative.



(i) Predict the polarity of V_G to create depletion charge in the B region and also find the suitable thickness of region A to ensure 10 nm channel from S to D in case region B develops a 10 nm depletion region.

(ii) If region B is illuminated with a light having photon energy more than band gap of the semiconductor , then comment on the conductance of channel A in case of V_G is positive and also negative. (12)

Q.2: A resonant tunneling diode is formed by using GaAs and $Ga_{0.2}Al_{0.8}As$ materials with well width as 4 nm and barrier thickness as 3 nm. Sketch and label the energy band diagram of the structure showing all possible quantum levels in the well assuming the first energy level in well is 80 meV. Sketch and label I Vs V, assuming positive resistance as 4 k ohm and valey voltage as 1.2 times of the peak voltage.(Assume peak to valey current ration as 3,effective $\Delta Ec = 1.4\ \Delta Ev$, Eg of GaAs and Al As are 1.42 eV and 2.16 eV respectively)

(6)

Q.3: A semiconductor quantum well laser is to be designed by usibg GaAs and $In_{0.4}Ga_{0.6}As$ as alternate regions and finds first quantum level as 60 meV. Predict the wavelength of the source under inter band recombination. Now this structure is being extended for intraband electron transition to generate photons by making quantum cascade laser. Sketch different regions showing tunneling regions and electron energy levels of the involved wells with suitable biasing.(Eg of InAs as 0.35 eV and effective mass of electron and holes are same)

(6)

Q.4:Design a double gate (both n + poly) MOSFET having top and bottom oxide as SiO_2 and thicknesses as 1.5 nm and 80 nm respectively. Assume channel is of p-type Si of thickness 10 nm. Sketch and label potential across the structure in the following cases :
(i) both are positive biased and film is partially depleted.
(ii) both are negative biased
(iii) top one is positive nad the bottom one is negative.
Compute the S (mV/decade)if the film is partially depleted and also if fully depleted. (6)

Q. 5 : Design all optical logical gates using optical waveguides, couplers and ring resonators to realize OR, AND and EXOR gates.

(5)

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