Alexandria University
Faculty of Engineering
Electrical Engineering Department
Mid-term Exam, November 2013

جامعة الإسكندرية
كلية الهندسة
قسم الهندسة الكهربية
امتحان نصف الفصل الدراسي الثاني (نوفمبر ٢٠١٣)

Course Title and Code Number:
Semiconductor Devices (EE336)
Third Year (Communications and Electronics)
Time Allowed: 45 Mins

اسم المقرر والرقم الكودي له:
النبآئط شبه الموصلة (EE336)
السنة الدراسية الثالثة (اتصالات و الكترونيات)
الزمن: ٤٥ دقيقة

Name:	**Seat number:**

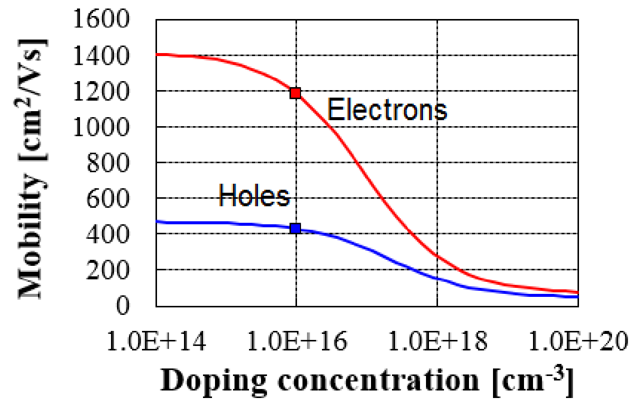
Answer All Questions in The Exam Paper: **(15 marks)**

Question 1: **(4 marks)**

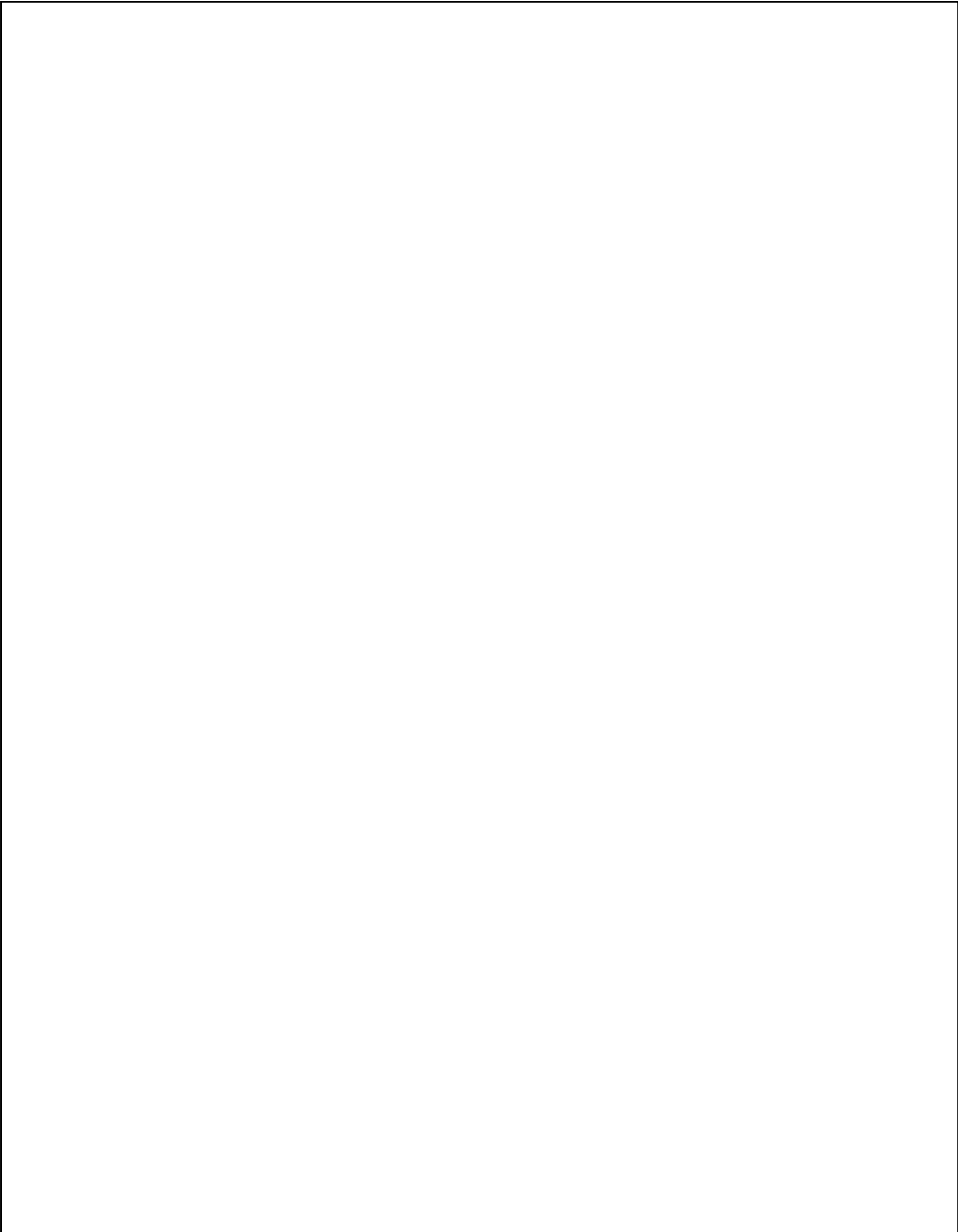
In the Czochralski process, a known amount of boron with a segregation coefficient $k_0 = 0.8$ is added to the melt to obtain the desired concentration.

a) **Derive** an expression for the doping concentration in a solid (C_s/C_0) as a function of the fraction solified (M/M_0).

b) Assuming that a 10 kg pure silicon is used, what amount of boron must be added to get boron-doped silicon having a resistivity of 0.01 Ω-cm when one half of the ingot is grown? The density of silicon is 2.338 g/cm^3 and atomic weight of boron is 10.8 g/mol.



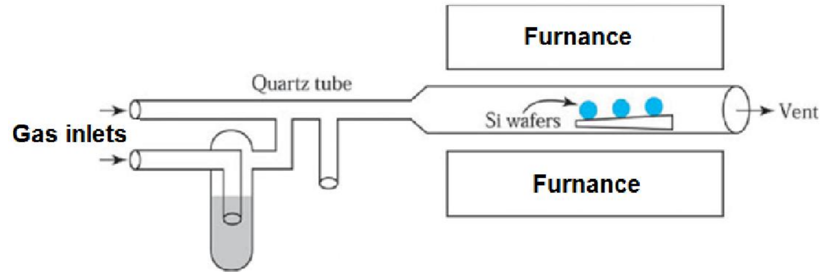
c) What will be the type (n or p) of a wafer produced by the above procedure? Is the dopant distribution uniform along the wafer diameter? If not, what is the region with larger impurity concentration (center or perimeter region)? And why?



Question 2: **(11 marks)**

Select the appropriate answer(s) of the following questions. You may select more than one choice if needed. Incomplete and incorrect answers will not be rewarded.

1. What is the fabrication process which use the following equipment shown in Figure?
    a. Oxidation
    b. Physical vapor deposition
    c. Ion implantation
    d. Chemical vapor deposition
    e. Chemical-mechanical polishing



2. The epitaxial layer is a …………… :
    a. amorphous silicon layer grown above a seed substrate wafer
    b. single crystalline silicon layer grown above a seed substrate wafer
    c. polysilicon layer grown above a seed substrate wafer
    d. single crystalline silicon layer grown from a seed crystal
    e. none of the above

3. The chemical vapor deposition (CVD) method for low temperature requirements is ………... :
    a. atmospheric-pressure CVD
    b. plasma-enhanced CVD
    c. RF sputtering
    d. low-pressure CVD
    e. none of the above

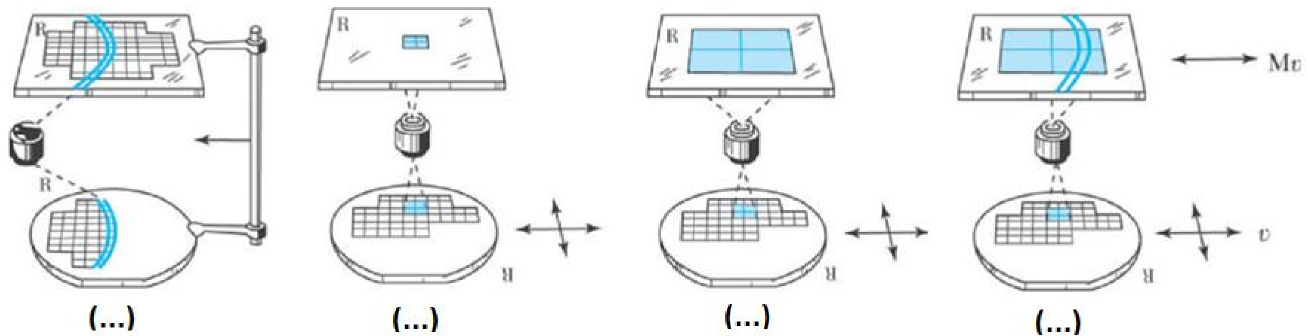
4. The primary semiconductor applications of physical-vapor deposition (PVD) technology are the deposition of …….. :
    a. polysilicon
    b. silicon nitride
    c. metal and compounds
    d. all of the above
    e. none of the above

5. The implanted impurity profile of ion implantation is …….. :
    a. erfc distribution with a maximum at the wafer's surface
    b. Gaussian distribution with a maximum at the wafer's surface
    c. uniform distribution
    d. Gaussian distribution with a maximum at a certain projection range
    e. none of the above

6. In a two-step diffusion process a pre-deposition layer is first formed under a ……….. :
    a. constant–temperature condition
    b. constant–surface–concentration condition
    c. constant–pressure condition
    d. constant–flux condition
    e. constant–total-dopant conditio

7. In a two-step diffusion process, the pre-deposition layer is followed by a drive-in diffusion under a …………. :
   a. constant–temperature condition
   b. constant–surface–concentration condition
   c. constant–pressure condition
   d. constant–flux condition
   e. constant–total-dopant condition

8. Assign the following lithographic projection techniques to the corresponding equipment on Figure.
   I. M:1 reduction step-and-scan
   II. 1:1 step-and-repeat
   III. annual-field wafer scan
   IV. M:1 reduction step-and repeat



9. Sort the following fabrication steps of an n-well process according to their precedence:
   I. polysilicon patterning
   II. metallization
   III. n-diffusion
   IV. n-well formation
   V. p-diffusion
   VI. contact creation

   (**1:** …), (**2:** …), (**3:** …), (**4:** …), (**5:** …), (**6:** …)

- For the following equation describing the oxide thickness in thermal oxidation:

$$x = \frac{D}{k}\left[\sqrt{1+\frac{2C_0\kappa^2(t+\tau)}{DC_1}}-1\right]$$

10. During the early stages of oxide growth, the oxide thickness varies …………. :
    a. linearly with time
    b. exponentially with time
    c. linearly with the reaction rate
    d. linearly with the reaction rate
    e. linearly with the diffusion coefficient

11. As the oxide layer becomes thicker, the oxide growth then becomes proportional to ……….. of the oxidizing time
    a. the square
    b. the root mean square
    c. the square root
    d. the inverse
    e. none of the above

Good Luck

Examiner: ***Dr. Mohammed Morsy***