Semiconductor basics

1.

(a) Describe how the temperature affects charge carrier mobility in single-crystal silicon. (5 pts)

(b) In polycrystalline silicon, explain how the temperature-mobility relationship is different from above. (5 pts)

2.

(a) What is the definition and physical meaning of the density of states (DOS)? (5 pts)

(b) What is the definition and physical meaning of the Fermi-Dirac distribution? (5 pts)

(c) Using the DOS and the Fermi-Dirac distribution, explain the charge carrier distribution with respect to the electron energy at room temperature in intrinsic, p-doped, and n-doped silicon samples respectively. (5 pts)

3. A P-N junction is formed in single-crystal silicon at room temperature (RT).

*N*A: 5×1017 atoms/cm3, *N*D: 3×1018 atoms/cm3, elementary charge: 1.6×10-19 C,  
intrinsic carrier concentration of silicon at RT: 1010 cm-3,  
vacuum permittivity: 8.85×10-14 F/cm, relative permittivity of silicon: 11.7

(a) Calculate the built-in potential (V). (5 pts)

(b) In Maxwell’s equations, what is the formula that describes the relationship between charge and electric field? (5 pts)

(c) Describe a simple relationship between electric field and potential. (5 pts)

(d) Plot the charge, electric field, and potential profiles respectively. Specify the depletion width in your answer. (20 pts)