1. 1. 1. VG > Vth; Since qΨB is 0.466 eV, and the gap between EF and Ei after the shift is 0.522 eV, the total shift is 0.988 eV, which is greater than 2qΨB = 0.466 eV \* 2 = 0.932 eV. If VG = Vth, the gap between EF and Ei after the shift would be 0.466 eV.
      2. VG < Vth; Since EF is still closer to EV than to EC after the shift, the depletion region is still p-type and has not yet become n-type. This means that VG is way less than Vth.
      3. VG < Vth; Since qΨB is 0.466 eV, and the gap between EF and Ei after the shift is 0.326 eV, the total shift is 0.792 eV, which is less than 2qΨB = 0.466 eV \* 2 = 0.932 eV. If VG = Vth, the gap between EF and Ei after the shift would be 0.466 eV.
   2. 1. When x = 0,

n = ND = NC \* e-(Ec-Ef)/kT = 1025 \* e-(0.55-0.522)/0.025 = 3.263\*1024 / m3

p = NA = NV \* e-(Ef-Ev)/kT = 1025 \* e-(0.522+0.55)/0.025 = 2.385 \* 106 / m3

When x = 60 nm,

n = ND = NC \* e-(Ec-Ef)/kT = 1025 \* e-(0.55+0.466)/0.025 = 2.24\*107 / m3

p = NA = NV \* e-(Ef-Ev)/kT = 1025 \* e-(0.522+0.55)/0.025 = 3.476\*1023 / m3

* + 1. When x = 0,

n = ND = NC \* e-(Ec-Ef)/kT = 1025 \* e-(0.55+0.14)/0.025 = 1.032\*1013 / m3

p = NA = NV \* e-(Ef-Ev)/kT = 1025 \* e-(0.55-0.14)/0.025 = 7.543\*1017 / m3

When x = 60 nm,

n = ND = NC \* e-(Ec-Ef)/kT = 1025 \* e-(0.55+0.466)/0.025 = 2.24\*107 / m3

p = NA = NV \* e-(Ef-Ev)/kT = 1025 \* e-(0.522+0.55)/0.025 = 3.476\*1023 / m3

* + 1. When x = 0,

n = ND = NC \* e-(Ec-Ef)/kT = 1025 \* e-(0.55-0.326)/0.025 = 1.284\*1021 / m3

p = NA = NV \* e-(Ef-Ev)/kT = 1025 \* e-(0.326+0.55)/0.025 = 6.058\*109 / m3

When x = 60 nm,

n = ND = NC \* e-(Ec-Ef)/kT = 1025 \* e-(0.55+0.466)/0.025 = 2.24\*107 / m3

p = NA = NV \* e-(Ef-Ev)/kT = 1025 \* e-(0.522+0.55)/0.025 = 3.476\*1023 / m3

1. Equation: Vth = (q\*Na\*W)/Cox \* 2qΨB, where Cox = (εoεox)/tox
   1. If NA increases, then Vth would increases
   2. If tox increases, then Cox decreases, and Vth increases
   3. If εox increases, then Cox increases, and Vth decreases
2. ΦB = |EF – Ei| / q

EF – Ev = -kT\*ln(NA/Nv) = -0.026\*ln[(7\*1018)/(1025)] = 0.3685eV

|EF – Ei| = 0.55 – 0.3685 = 0.1815 eV = ΨB

ΨB = |EF – Ei| / q = ΨB / q = 0.1815eV / (1.602\*10-19) = 1.133 \* 1018 eV/C

Cox = εoεox / tox = (8.854\*10-12 F/m \* 4) / (8 \* 10-9) m = 0.004427 F = 4.427 mF

Wmax = sqrt[(2εoεSi\*2ΨB)/(q\*NA)] = sqrt[(2\*8.854\*10-12\*12\*2\*0.1815)/(1.6\*10-19\*7\*1018)]

= 8.299\*10-6 m

Vth = sqrt(4\*εoεSiq\*NA\*ΨB)/Cox + 2ΨB

= sqrt(4\* 8.854\*10-12\*12\*1.6\*10-19 \* 0.1815)/0.004427 + 2\*0.1815

= 0.363 V

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