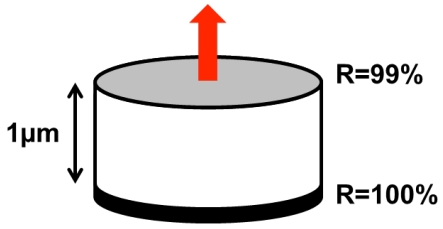
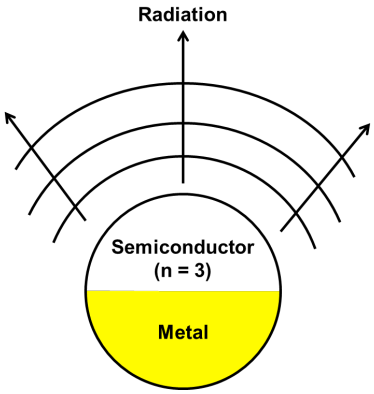
HW #1
For practice. No due date.

1. Consider a vertical cavity surface-emitting laser with a top mirror reflectivity of 99% and a bottom mirror reflectivity of 100%, an effective cavity length of 1μm, and a diameter of 2 μm. The confinement factor is 100%. The residue loss of the active media is $10cm^{-1}$ and the refractive index is 3.5. The laser wavelength is 1 μm.



   a. Find the quality factor (Q) of the cavity.
   b. Find the threshold gain and quantum efficiency of the laser.

2. Consider a laser with metallodielectric cavity shown on the right. It consists of a 100-nm-diameter spherical cavity with half metal and half semiconductor. Assume 30% of the energy is in the metal, and the remaining 70% is in the semiconductor. The quality factor of the metal is 50 (note: the Q of a material describes the loss of that material, it is different from the cavity Q). Assume the residue loss in semiconductor is negligible (i.e., its material Q is ∞). The cavity acts like a dipole antenna and radiates optical energy (i.e., output light). Assume the radiation Q is 500 (i.e., the Q associated with the radiation loss is 500). The laser wavelength is 1 μm.



   a. What is the total Q of the cavity?
   b. What is the threshold gain and quantum efficiency of the laser?