School of Electrical and Computer Engineering, Cornell University

ECE 303: Electromagnetic Fields and Waves

Fall 2007

Homework 9 **Due on Oct. 26, 2007 by 5:00 PM**

Reading Assignments:

i) Review the lecture notes.
ii) Review sections 6.4-6.5 of the paperback book *Electromagnetic Waves*.

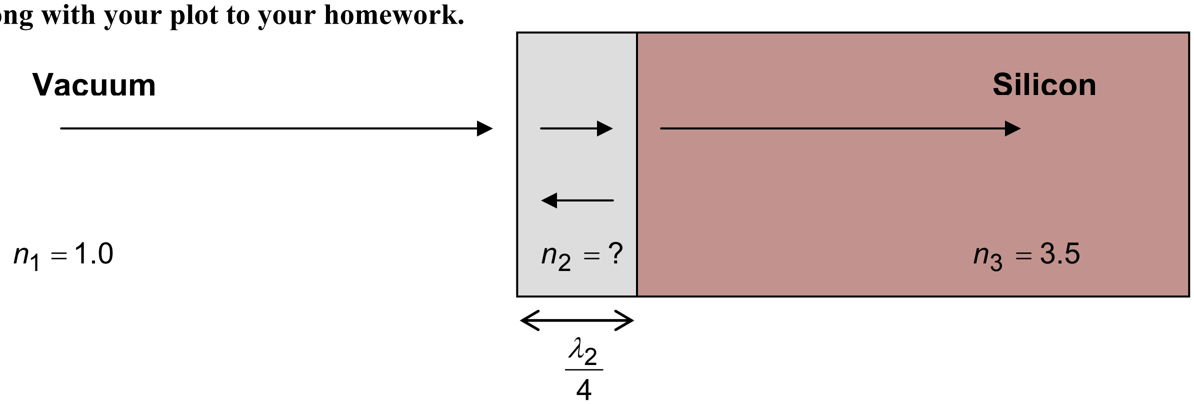
Special Note: Graders have been instructed to take off points (as much as 50%) if proper units are not included in your numerical answers. You must specify the correct units with your numerical answers.

Problem 9.1: (Design of AR coatings)

You have been hired by NASA for their top-secret spy satellite program. Your job is to design a Silicon CCD camera that can image any vehicle on Earth while in an orbit. Your first task is to design an AR coating for the camera. The AR coating has to be such that light incident from vacuum has zero reflection coefficient for the wavelength corresponding to green light (wavelength 0.52 μm in vacuum).

a) You choose a single dielectric layer quarter-wavelength thick to make the AR coating. What ought to be the refractive index and thickness (in meters) for this coating layer?

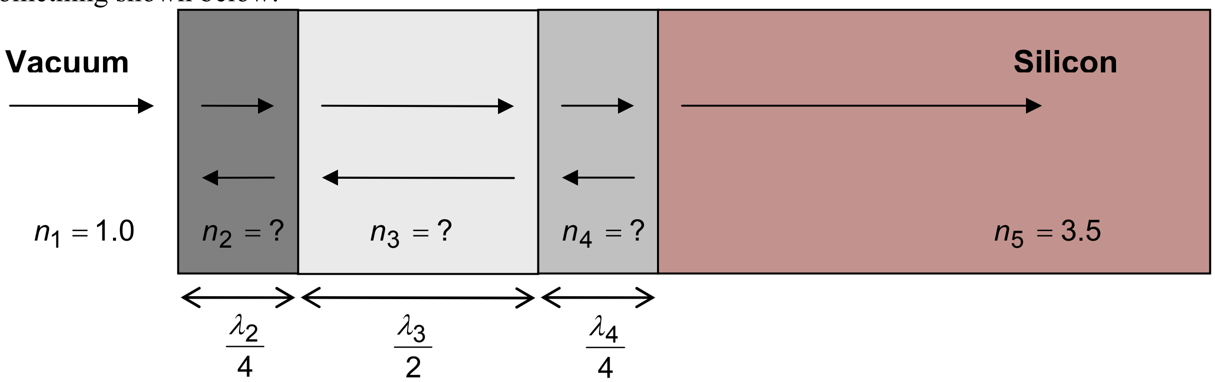
b) Generate a plot of the reflectivity $|\Gamma|^2$ vs the vacuum wavelength of the incident light to see how good the single layer AR coating performs for wavelengths other than the design wavelength of 0.52 μm. **Your plot should look like the one in the lecture notes (check to make sure)**. To generate this plot you will need to write a Matlab routine to calculate the reflectivity for vacuum wavelengths starting from 0.3 μm to 0.9 μm. **You cannot borrow or copy Matlab routine from other students. Attach your routine along with your plot to your homework.**



Having designed your AR coating you go and tell your boss about your success. Your boss looks at you with amazement and informs you that no material exists in the world that has the refractive index you want for your AR coating. Disappointed, you go to the stock room and after a brief search find only the following three materials:

Material A (refractive index: 2.8)
Material B (refractive index: 2.25)
Material C (refractive index: 1.5)

You need to design a good AR coating using only the above materials. You are stuck! You go to your boss and ask for help. He says, "try a quarter-half-quarter stack". You figure that he wants you to try something shown below:

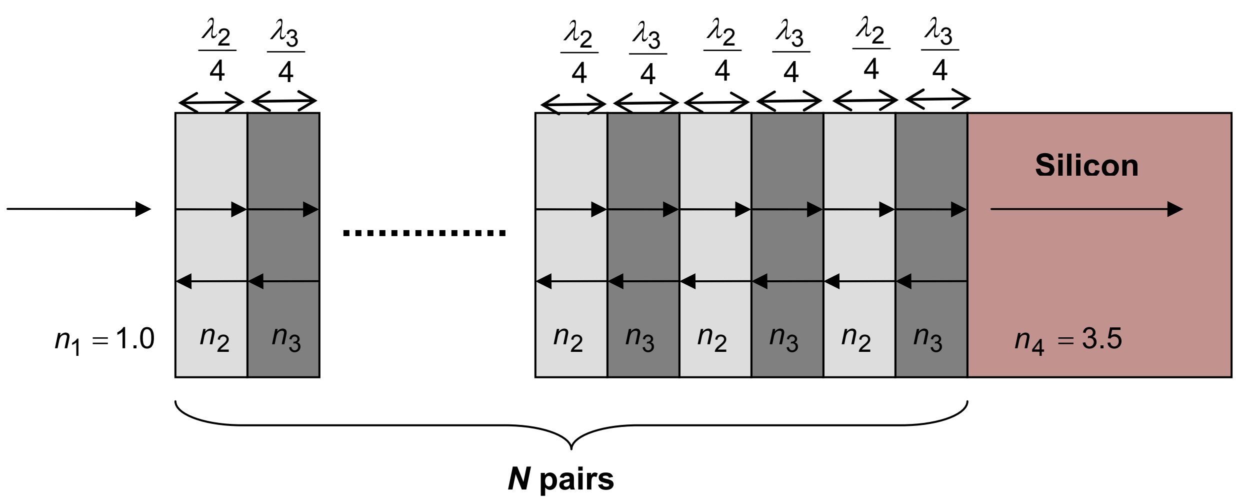


c) What ought to be the refractive indices and thicknesses (in meters) of each one of the three coating layers to get reflectivity zero (or close to zero) for the design wavelength corresponding to green light? Your coating layers can only be one of the three materials available to you. You need to think carefully here about what is going on.

d) Using your results in part (c), generate a plot of the reflectivity $|\Gamma|^2$ vs the vacuum wavelength of the incident light to see how good the multiple-layer AR coating performs for wavelengths other than the design wavelength of 0.52 μm. To generate this plot you will need to write a Matlab routine to calculate the reflectivity for vacuum wavelengths starting from 0.3 μm to 0.9 μm. **You cannot borrow or copy Matlab routine from other students. Attach your routine along with your plot to your homework.**

Problem 9.2: (Design of HR coatings)

In this problem you will compute the characteristics of HR coatings that employ a multilayer stack of high index-low index pairs, as shown below.



Suppose the indices are as follows: n_2=2.4 (corresponding to Silicon dioxide) and n_3=1.5 (corresponding to Titanium dioxide). You need to design an HR coating for wavelength corresponding to that of green light in vacuum (0.52 μm).

a) What ought to be the thicknesses (in meters) of the layers in the HR coating with indices 1.5 and 2.4?

b) Generate a plots of the reflectivity $|\Gamma|^2$ vs the vacuum wavelength of the incident light to see how good the HR coating performs for wavelengths other than the design wavelength of 0.52 μm. To generate these plots you will need to write a Matlab routine to calculate the reflectivity for vacuum wavelengths starting from 0.3 μm to 0.9 μm. You need to generate 6 separate plots for the following values of the number of pairs in the HR coating: N=1, 2, 4, 8, 16, 32. **You cannot borrow or copy Matlab routine from other students. Attach your routine along with your plot to your homework.**