Exercise 2: Photonic bandgap materials

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| Group | Student 1 |
|  | Student 2 |
| Date | Assistant |

Staple the graphs, which you base your analysis on, to the answer form.

The level of detail of a complete answer is such that the answer fits in the box if typed in average handwriting.

Instead of typing in the boxes below, you may write on separate sheets.

The numbering of the questions below refers to the corresponding report instruction. Notice that not all the latter questions will be considered in this form assignment.

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| 2- Describe the structure of an artificial opal and calculate the filling factor for the close packed fcc structure. Locate the 111 planes in the unit cell of the structure (draw a picture) and calculate the interplane distance, d111, with respect to the diameter of the spheres, D.  |
| 2- Derive the optical Bragg equation for the structure by assuming that the light is reflected from 111 crystal planes, whose spacing is d111. Hints on how to do this are given in App. A. By using the effective medium approximation, calculate the effective refractive index for the colloidal crystals. Your samples consist of polystyrene, whose refractive index n = 1:59 [8]. |
| 5- Measure the particle sizes from the electron microscope images found on the exercise web page. A good program to use is ImageJ (http://rsb.info.nih.gov/ij/). If needed, the assistant can give advice on using ImageJ. Measure at least 20 particles from each sample and calculate the average size and the standard deviation of the size. Remember to describe the process and put your data in a table. Include also the particle sizes supplied by the manufacturer (page 12). Which particle sizes data (DLS or electron microscopy) should you use in the data analysis in this work? Justify your choice.  |
| 6- Plot the spectra of the colloidal crystals (transmittance or absorbance) and locate the bandgap. You need to reduce the effect of the substrate from your spectra. Estimate the accuracy of the location of the bandgap. Discuss the sources for error in the measurements.  |
| 8- Plot the location of the bandgaps as a function of angle in $λ^{2}$/$sin^{2}$ ($θ$) -graph. You will end up with a straight line when you do this correctly. Remember to make error estimations with error curves. Again, you need to extract the error limits for the slope. Plot the appropriate theoretical curves and compare them to your measurements. Try to make the correlation better by varying some parameter. Again, justify your choice. |
| 9- Analyze the optical microscope images. What can you see in the images? Comment on the quality of your samples. Can you suggest improvements for the sample preparation procedure? Read section 3 from the review article “Self-Assembled Photonic Structures”. |