# Lab rotation on optical properties of multilayer thin-films

## Objectives

- Gain experience in the deposition of thin organic (polymeric) films.
- Gain experience in measuring film thickness using a surface profiler.
- Experience in the design of an optical multilayer structure using transfer matrix model.
- Gain experience in the measurement of white light optical reflectivity.

## Experiments

Your task is to design, fabricate and characterise a multilayer dielectric mirror (distributed Bragg reflector). You should design your mirror using the online transfer matrix reflectivity (TMR) model http://pvlink.org/mlm/#. You should design your mirror such that it has a peak reflectivity at around 600 - 700 nm.

To fabricate your mirror, you have been provided with two polymers that are soluble in orthogonal solvents. This means that one film can be spin-coated onto an underlying layer without causing it to be removed.

Once you have fabricated your mirror, you should measure its white-light reflectivity and transmission as a function of viewing angle using the angle-dependent reflectivity setup provided. Make sure you characterise key parameters such as peak reflectivity wavelength and spectral width of the DBR stop band. Use both the TMR and experiments to explore how the mirror properties vary as a function of the number of mirror pairs.

**Sample preparation, hints and tips**: Make sure you wear lab-coat, goggles and gloves when processing and handling chemicals.

You have been provided with two polymer samples in solution: PMMA and PAZO.

The PAZO is solubilised from methanol, the PMMA from toluene. Because of the differing solubility of the materials, it is possible to spin-cast one material onto the other without damaging the underlying layer. Make sure you exercise caution when using toluene as it is toxic and flammable. It should only be handled in the fume hood provided.

To create a thin film, use the spin-coater that is housed in the fume hood. When using the spin-coater, place the glass slide on the spin-coater chuck and gently press it into the recess. Select the required speed using the control panel. You typically need 40 to 60 s spin-time to prepare a film. Start the spin-coater running, and then dispense 50 μL polymer solution onto the surface (so-called ‘dynamic dispense’).

## Film-thickness measurement, hints and tips:

On start-up, allow the Dektak to go through its initialisation routines.

To measure film thickness using the Dektak, make a small scratch in the film using a sharp object (e.g. tweezers). Place the sample on the centre of the stage, with the scratch line running parallel to the edge of the work-bench.

To setup the experiment, click on ‘Measurement Setup’ from the toolbar.

Set scan-length to 2000 μm.

Position the stylus one side of the scratch, and click ‘Tower down’. Watch the stylus approach the surface. Never touch the stylus.

Use the cross-hair to move the sample under the stylus. When close to the scratch, click ‘Measurement’.

The system will automatically plot the surface topology. Move the M and R cursors either side of the scratch. Then click on ‘Data leveling’ on RHS of the screen.

Move one cursor to the bottom of the scratch to record the scratch depth. Record this number in your lab-book.

Click on ‘Measurement setup’ to return to the main measurement page.

Repeat this measurement two or three times for each film until you are confident that you have determined film thickness with reasonable repeatability.

Click ‘Tower up’ to retract stylus. Never touch the sample when the stylus is down.

**Optical reflectivity: hints and tips**

Turn on both deuterium and halogen lamps. Check that light is delivered by your fibre, and then focussed onto the surface of your sample (use a small piece of paper to do this). Follow the reflected beam. Check this light is collected by the fibre-optical cable that is connected to the spectrometer. Remember you will need to adjust the angle of the two rails to deliver and collect the light (angle of incidence = angle of reflection).

As a dummy sample, you should use the piece of silver mirror provided. This will allow you to set a baseline for your experiments.

To measure reflectivity, first block the beam and take a dark reference spectrum (black bulb). Then unblock beam (no sample in place) and record a reference spectrum. This can be seen by pressing “I”. If this seems saturated, then re-position fibres and try again. To measure a sample, place sample over measurement hole and record absorption spectrum, (Press “A”). For absorption measurements, play around with the integration time (between 10 and 100 ms works well) with an average of 2 – 5 scans.

All data should be stored in .csv format. Periodically review your data to check that it is OK and that you are taking good data.