Photonic Crystals
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In order to improve thin film solar cell efficiency, it is important to enhance the optical path length by trapping light in the cell. We have successfully developed a new light-trapping scheme, which combines a reflection grating in the substrate with a distributed Bragg reflector (DBR). It can enhance optical path length by more than $10^4$ times with little loss of reflection. Consequently, incident light can be almost completely absorbed. In turn, we expect the quantum efficiency of the solar cell based on our photonic structure to be improved significantly.

In the year 2004, we achieved rapid progress in several aspects:

- We have fabricated high-quality DBRs with extremely high reflectivity that agrees well with simulation. For instance, using 5 pairs of Si/Si$_3$N$_4$ gives a reflectivity of 99.6%, whereas that for Si/SiO$_2$ is 99.98%.
- We have successfully developed a practical fabrication process for the silicon grating DBR by the following steps: first, optical projection lithography is used to pattern the Si substrate into gratings with periods on the order of wavelength; then a plasma etch is used to accurately control etch-depth; the last step is to deposit DBR stacks using LPCVD or DCVD. Figure 1 is the SEM image of Si grating with one pair of Si$_3$N$_4$/Si.
- Our Si grating displayed strong light bending effects (Figure 2). We have set up a measurement system that has a tunable-wavelength laser source and a detector that can be rotated over 180 degrees, allowing accurate determination of the reflected light direction and intensity.

The next step is to integrate the new back-reflector with simple solar cells to verify cell-efficiency improvement.

REFERENCES: