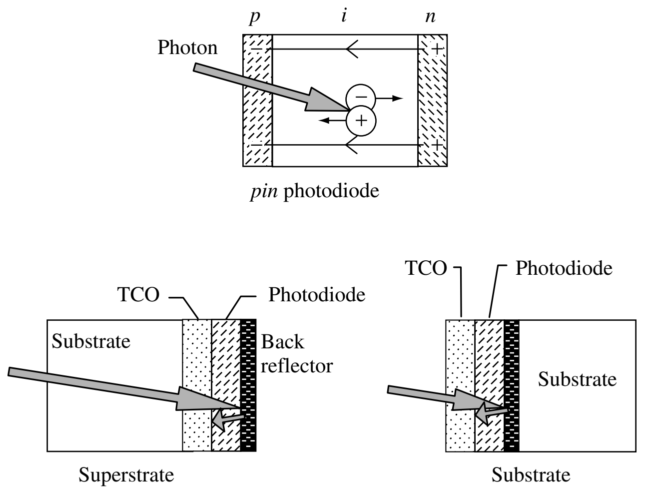

Figure 12.3 In a *pin* photodiode, excess electrons are donated from the n-type to the p-type layers, leaving the charges and electric fields illustrated. Each photon absorbed in the undoped, intrinsic layer generates an electron and a hole photocarrier. The electric field causes these carriers to drift in the directions shown. *pin* diodes are incorporated into solar cells in either the superstrate or substrate designs. For amorphous silicon–based cells, photons invariably enter through the p-type window layer as shown here

For doped a-Si:H, it turns out that minority photocarriers (holes in n-type a-Si:H, electrons in p-type a-Si:H) do not move very far, and so a p-n structure would only collect photocarriers from photons generated in an extremely thin layer of doped a-Si:H. Indeed, in analyzing the performance of a-Si:H-based solar cells, one normally considers any photons absorbed by the doped layers to be "wasted." The trick of keeping the doping atoms out of the absorber layer enables this layer to be thick enough to capture most of the sunlight.

In Section 12.4 you will find a more detailed description of the device physics of the *pin* solar cell; the description explains why the window layer is the p-type one, and also explains the design trade-offs that determine the thickness of the absorber layer.

12.1.2.2 Substrate and superstrate designs

One of the advantages of amorphous silicon–based solar cells is that they absorb sunlight very efficiently: the total thickness of the absorbing layers in amorphous silicon solar cells is less than 1 μm. Consequently, these layers need to be supported on a much thicker substrate. Two totally different designs for amorphous silicon solar cells have evolved corresponding to transparent and opaque substrates. We have illustrated the two designs in Figure 12.3.

In the "superstrate" design, sunlight enters through the transparent substrate, which is usually glass or a transparent plastic. The insulating substrate needs a conducting layer, which is typically a "transparent conductive oxide" (TCO) such as SnO_2. The amorphous silicon photodiode layers are then deposited onto the TCO, starting with a p-type window