coefficients of the electrons in nanocrystalline TiO_2 film have been estimated to be 1×10^{-7} [60] and 1.5×10^{-5} $cm^2\,s^{-1}$ [61]. In the DSSC, the electron conductivity of TiO_2 film is significantly increased due to electron injection from photosensitizers under photon irradiation [62, 63]. In addition, conductivity and response of the photocurrent increase with increasing incident light intensity [62, 63]. It has been suggested that when injected electrons fill the trap site and/or surface levels in the TiO_2 film, the diffusion coefficient of the electron increases drastically, leading to elevated electron conductivity and good response of the photocurrent.

15.1.5 Characteristics

As described above, the photovoltaic (PV) mechanism of DSSC is different from that of conventional *p-n*-type solar cells. The DSSC has other unique characteristics such as the following:

1. *High energy conversion efficiency*: A DSSC efficiency equal to that of the amorphous-Si solar cell has been obtained during laboratory development and efficiencies greater than 10% may be possible.
2. *Low-cost fabrication*: The DSSC is very simple to construct and is made of low-cost materials. Fabrication costs will therefore be less than that for conventional solar cells. For example, US$0.60/W, which may be competitive for conventional solar cells, has been estimated for a DSSC with 10% efficiency [10, 15].
3. *Abundant supply of component materials*: Oxide semiconductors such as TiO_2, dye, and iodine are abundantly available. Although metal deposits of Ru are limited, the amount of Ru complex used in the DSSC is only 1×10^{-7} $mol\,cm^{-2}$. As discussed in Section 15.3.2.2, organic dye photosensitizers could be used rather than Ru complexes if resource limitation is a problem.
4. *Good potential for colorful, adaptable consumer products*: Colorful and transparent solar cells can be made using various kinds of dyes, depending on the use of the cell. For example, transparent solar cells could be used in place of windowpanes. Additionally, the use of a plastic substrate, rather than glass, is possible if low temperature processing of the TiO_2 film preparation ($<250°C$) is available and would expand the use of DSSC.
5. *Low potential for environmental pollution*: The TiO_2, dyes, and iodine used in the DSSC are nontoxic. The only component that could potentially cause harm is the organic solvents used in the electrolyte solution. Future research should be directed toward developing a solid-state electrolyte.
6. *Good recyclability*: The organic dye photosensitizers adsorbed on the electrode can be removed by washing the electrode with alkali solutions or combustion, providing recyclability of the DSSC.

15.2 DSSC FABRICATION ($\eta = 8\%$)

15.2.1 Preparation of TiO_2 Colloid

Commercial powders of TiO_2, such as P25 (Degussa or Nippon Aerosil [75]), can be used to fabricate the TiO_2 photoelectrode. Colloidal TiO_2 prepared by hydrolysis of Ti(IV)