Example 4.6 A 1 cm^2 silicon solar cell has a saturation current of 10^{-12} A and is illuminated with sunlight yielding a short-circuit photocurrent of 25 mA. Calculate the solar cell efficiency and fill factor.

Solution The maximum power is generated for:

$$\frac{dP}{dV_a} = 0 = I_s(e^{V_m/V_t} - 1) - I_{ph} + \frac{V_m}{V_t} I_s e^{V_m/V_t}$$

where the voltage, V_m, is the voltage corresponding to the maximum power point. This voltage is obtained by solving the following transcendental equation:

$$V_m = V_t \ln \frac{1 + I_{ph}/I_s}{1 + V_m/V_t}$$

Using iteration and a starting value of 0.5 V one obtains the following successive values for V_m:

$$V_m = 0.5,\ 0.542,\ 0.540 \text{ V}$$

and the efficiency equals:

$$h = \left| \frac{V_m I_m}{P_{in}} \right| = \frac{0.54 \times 0.024}{0.1} = 13\,\%$$

The current, I_m, corresponding to the voltage, V_m, was calculated using equation (4.6.1) and the power of the sun was assumed 100 mW/cm^2. The fill factor equals:

$$\text{fill factor} = \frac{V_m I_m}{V_{oc} I_{sc}} = \frac{0.54 \times 0.024}{0.62 \times 0.025} = 83\,\%$$

where the open circuit voltage is calculated using equation (4.6.1) and $I = 0$. The short circuit current equals the photocurrent.