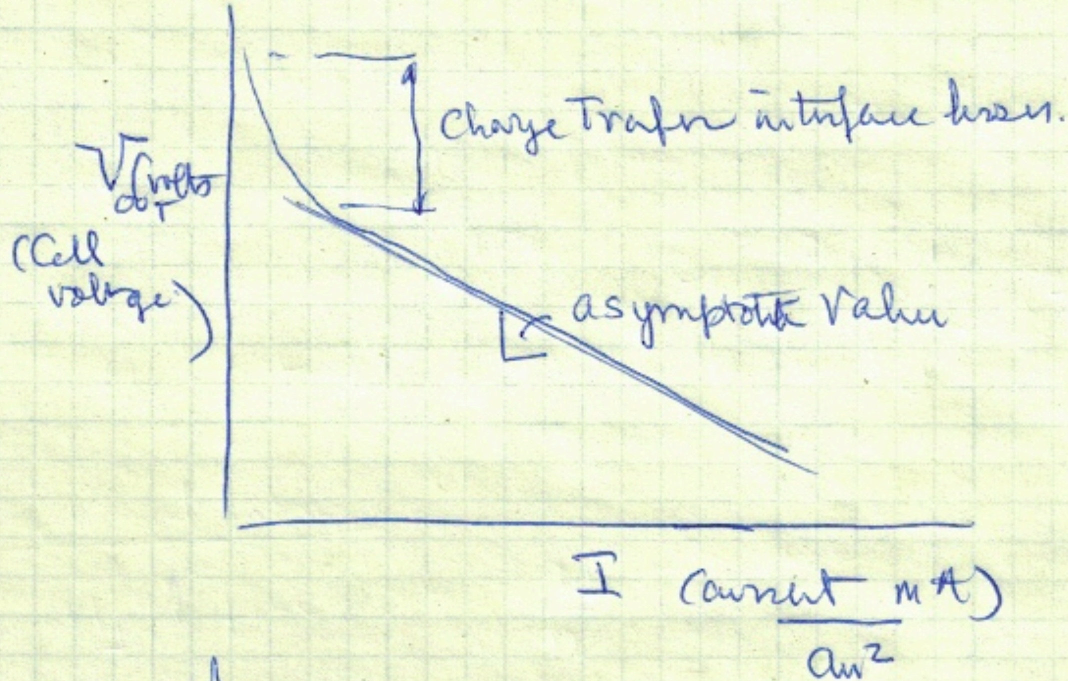
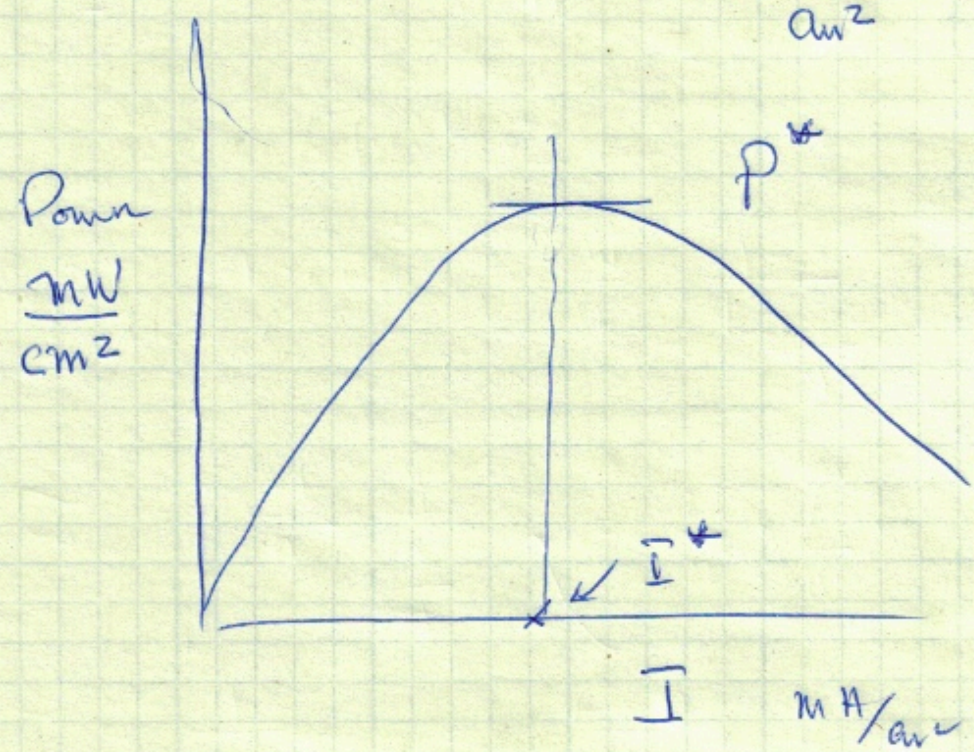
Analysis of the performance Parameters in Fuel Cells.

Fuel Cell performance is characterized by the following two plots.

(i)



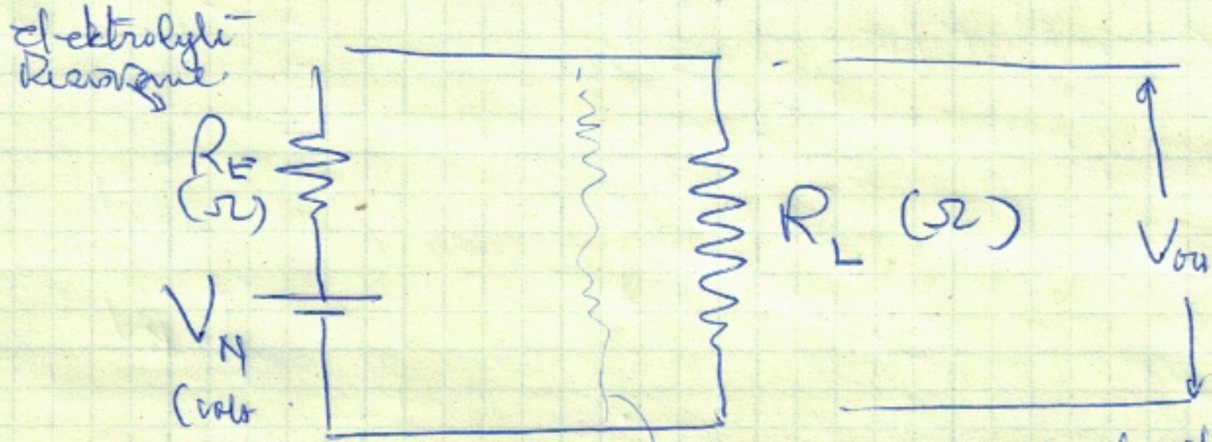
(ii)



Note that current & power density are normalized with respect to the surface area of the cell.

In the following analysis we shall consider P in W and the current in A (but using the same nomenclature as in p.1)

Equivalent circuit -



electronic conductivity in the electrolyte as neglected.

$$I = \frac{V_N}{R_E + R_L} \qquad \text{—— ①}$$

$$V_{OUT} = V_N \times \frac{R_L}{R_E + R_L} \qquad \text{—— ②}$$

Since I is controlled by reducing R_L with effect. we need to eliminate R_L from ① & ②

from ① $$R_L = \frac{V_N}{I} - R_E \qquad \text{—— ③}$$

for ③ $$R_E + R_L = R_L \left[\frac{V_N}{V_{OUT}}\right]$$

$$R_L\left[\frac{V_N}{V_{OUT}}-1\right] = R_E$$

$$R_L = \frac{R_E}{\left[\frac{V_N}{V_{OUT}}-1\right]} \quad \text{— } 4$$

Eliminate R_L for ~~1 & 2~~ 3 & 4

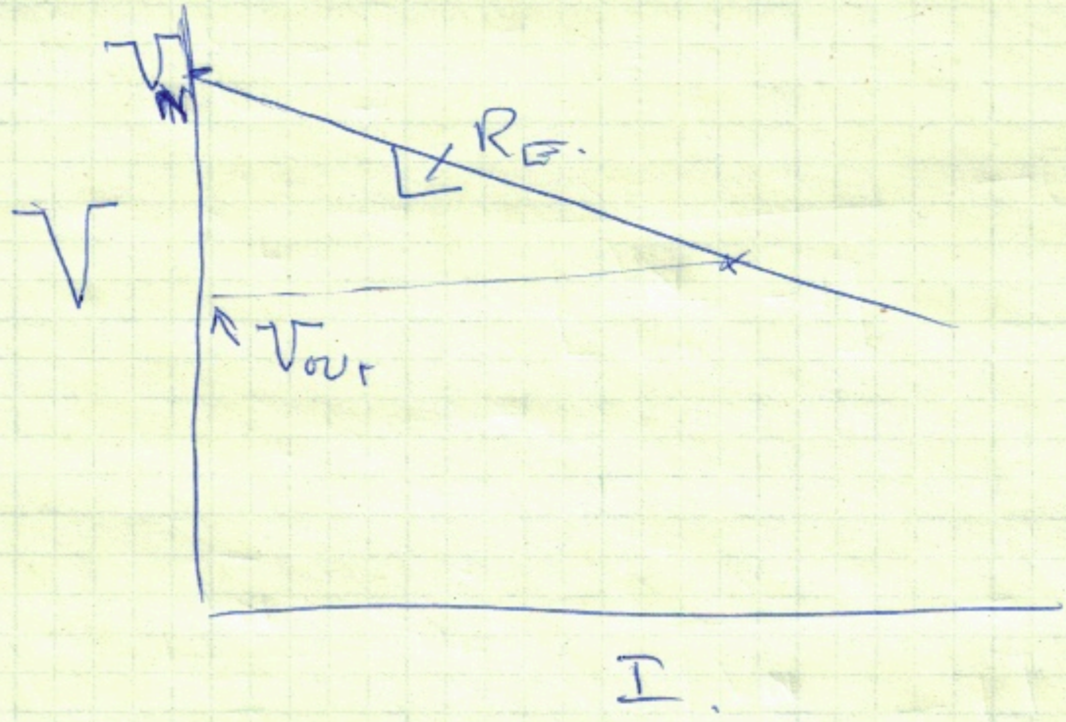
$$\frac{V_N}{I} - R_E = \frac{R_E}{\left[\frac{V_N}{V_{OUT}}-1\right]}$$

$$\frac{V_N}{I} = R_E\left[\frac{1}{\frac{V_N}{V_{OUT}}-1} + 1\right]$$

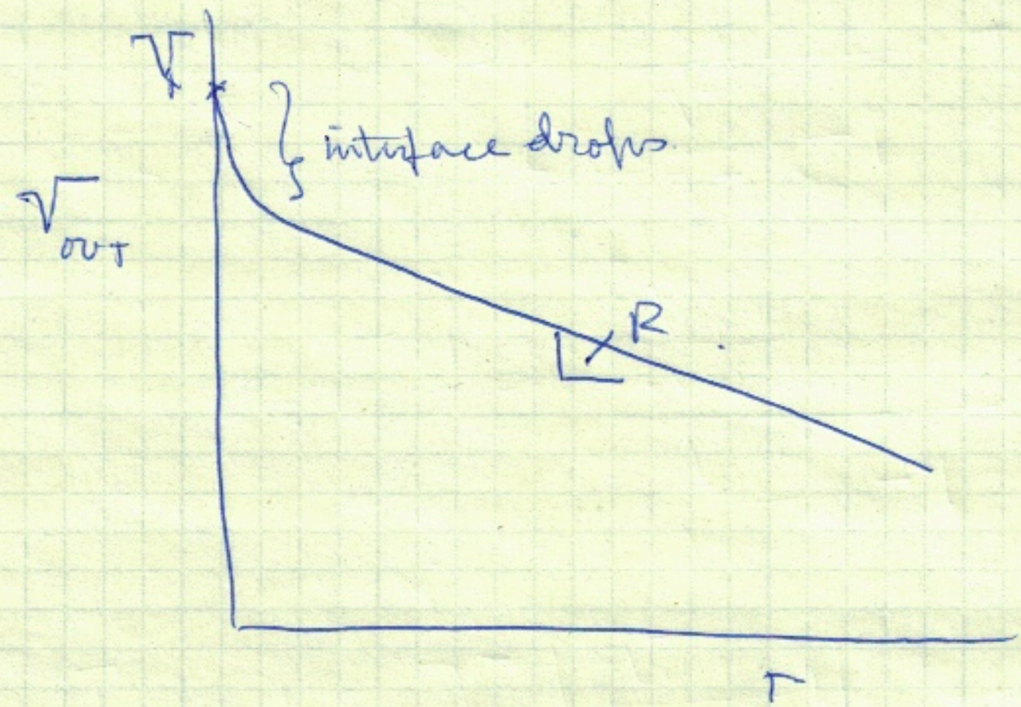
$$= R_E \times \frac{\frac{V_N}{V_{OUT}}}{\frac{V_N}{V_{OUT}}-1}$$

$$I = \frac{1}{R_E} \times \frac{V_N\left[\frac{V_N}{V_{OUT}}-1\right]}{\frac{V_N}{V_{OUT}}}$$

$$\therefore\ I = \frac{V_N - V_{OUT}}{R_E} \quad \text{———— } 5$$



But because of interface effects



Power output = $V_{OUT} \times I$.

from Eq (5)

$$V_{OUT} = V_N - IR_E$$

$$P = IV_N - I^2 R_E \quad \text{— (6)}$$

To find the Max

$$\frac{dP}{dI} = V_N - 2I^* R_E = 0$$

$$\therefore \boxed{I^* = \frac{V_N}{2R_E}} \quad \text{— (7)}$$

(6) + (7)

$$P^* = \frac{V_N^2}{2R_E} - \frac{V_N^2}{4R_E^2} \times R_E$$

$$\boxed{P^* = \frac{V_N^2}{4R_E}} \quad \text{— (8)}$$

Note that Eqns (7) & (8) illustrate the great significance of R_E!