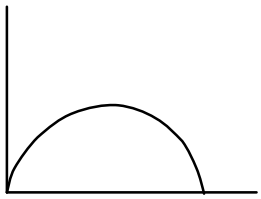
**Module 5715 Tutorial JTSI**
Friday 25th April room 204

1. The impedance of a single RC parallel element is given by

$$Z' = \left[\frac{R}{1+(\omega RC)^2}\right] \qquad Z'' = \left[R\frac{\omega RC}{1+(\omega RC)^2}\right]$$

Sketch this in Nyquist format (Z"vs Z'), using limiting values of frequency to guide the drawing. What is significant at the frequency point determined by ωRC=1.

ω = 0 Z' =R Z" = 0
ω = 1/RC Z' =R/2 Z" = R/2
ω = ∞ Z' =0 Z" = 0
ωRC=1 max in Z", relaxation frequency, characteristic frequency of response



2. What do you understand by the brick wall model that is used to describe the electrical response of a typical ceramic? What are the main electrical characteristics that allow the spectroscopic separation of grain interior (bulk) and grain boundary in impedance plots.

Conducting grains separated by less conducting but very thin grain boundaries. The capacitance of the element is the key variable, as most materials have similar order og delectric constants then this scales with thickness

3. What are the principal differentiators between the structures and characteristics of a supercapacitor and a secondary lithium battery?

Supercapacitor normally has same electrodes with very high surface area. Battery has different electrodes. Open circuit voltage of battery depends on electrodes whereas super capacitor discharges to zero volts. Battery is based upon charge transfer processes whereas supercapacitor is principally electrode polarisation. There is some cross over with eg Faradaic behaviour in pseudocapacitors

4. In what ways does an oxygen transport membrane resemble a solid oxide fuel cell and in what ways do they differ.

"electrode" materials are similar with similar electrochemical function, but no current collection in OTMs. Electrolyte in SOFC pure ionic, in OTM membrane is mixed ion/electron. OTM relates to chemical potential, SOFC to electrochemical potential

5. Suggest a materials set that might be utilised in a current secondary lithium ion battery.

LiCoO2 +ve, graphite –ve polyethylene mesh soaked with EC/DMC with 1M $LiPF_6$

What approaches are being considered to improve the following characteristics of lithium ion batteries

(i) power output nanostructures, increasing voltage

(ii) energy storage capacity increasing voltage, alternative positives eg Li/air, LiS, -ve Si, Li

(iii) cost and environmental impact. Mn,Fe vs Co, Na vs Li

6. The ionic resistance of 1%$CdCl_2$ doped NaCl decreases with temperature according to Arrhenius behaviour, with an increase in activation energy for conduction from 0.7eV to 1.3 eV at 500$^o$C as temperature increases. Sketch this on a schematic Arrhenius type plot and suggest why this change occurs. Extrinsic to intrinsiv

   Also add to this diagram a plot showing how the traces for 2% and 3% doping of NaCl with $CdCl_2$ would appear.