

Toward A Highly Efficient Ceria-Based Composite Electrolyte

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Outline

1. Introduction To Composite Electrolyte

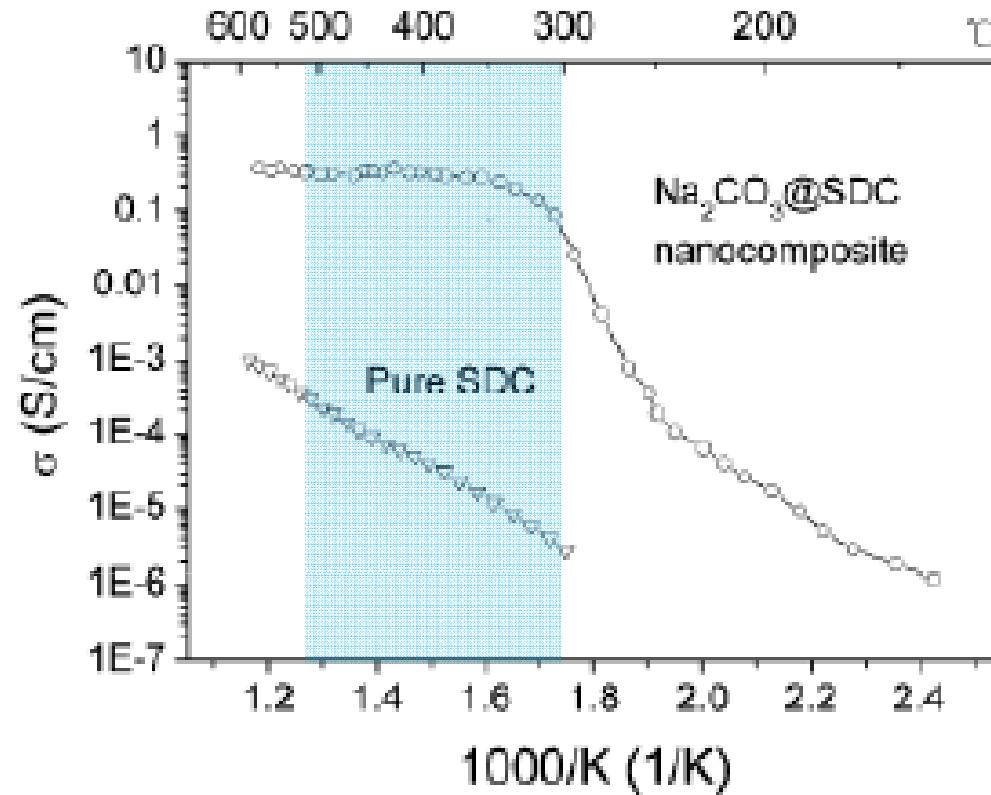
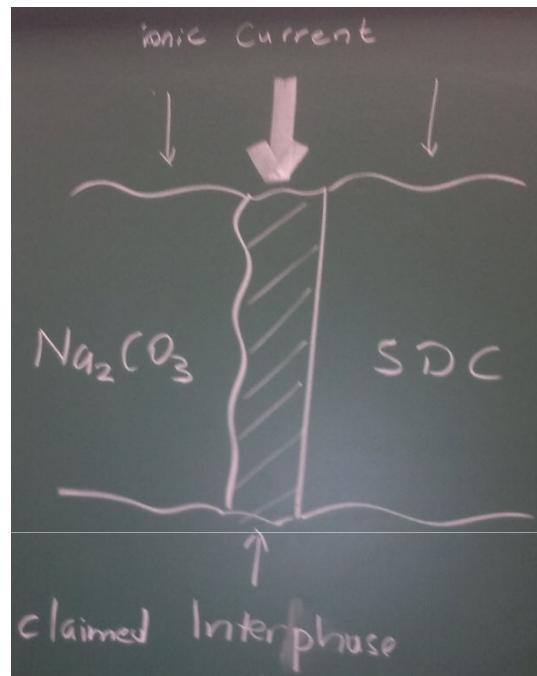
2. Methodology

3. Results

4. Summary

5. Acknowledgement

1. Ionic Transport in Composite Electrolyte

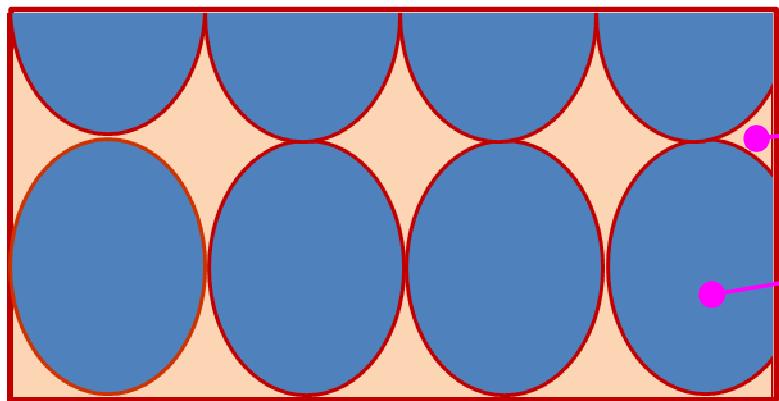


X.D. Wang, Y.Ma, R. Raza, M, Muhammed, B. Zhu, Electrochim. Commun. 10 (2008) 1617

Aim: To figure out role of the amount of contact interface between Na_2CO_3 and SDC ($\text{Sm}_{0.2}\text{Ce}_{0.8}\text{O}_x$) thus to study its relation with improved ionic conductivity.

2. Methodology: Control interface density through particle size

SSA 11 m²/mg

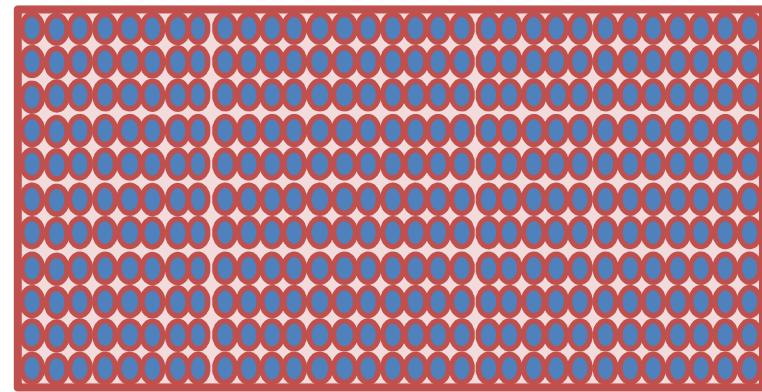


crystallite size of $0.2\mu\text{m}-1.4\mu\text{m}$

$\text{Sm}_{0.2}\text{Ce}_{0.8}\text{O}$ (SDC)

Specific surface area
(SSA) $\cong (1/r)$

SSA 200 m²/mg



crystallite size of $5\text{nm}-10\text{nm}$

Weight ratio of micron sized /Nano sized SDC	Only micron sized	1.41	1.00	0.54	Only Nano sized
Specific surface area (SSA) (m ² /mg)	50	100	120	150	200

2. Aims

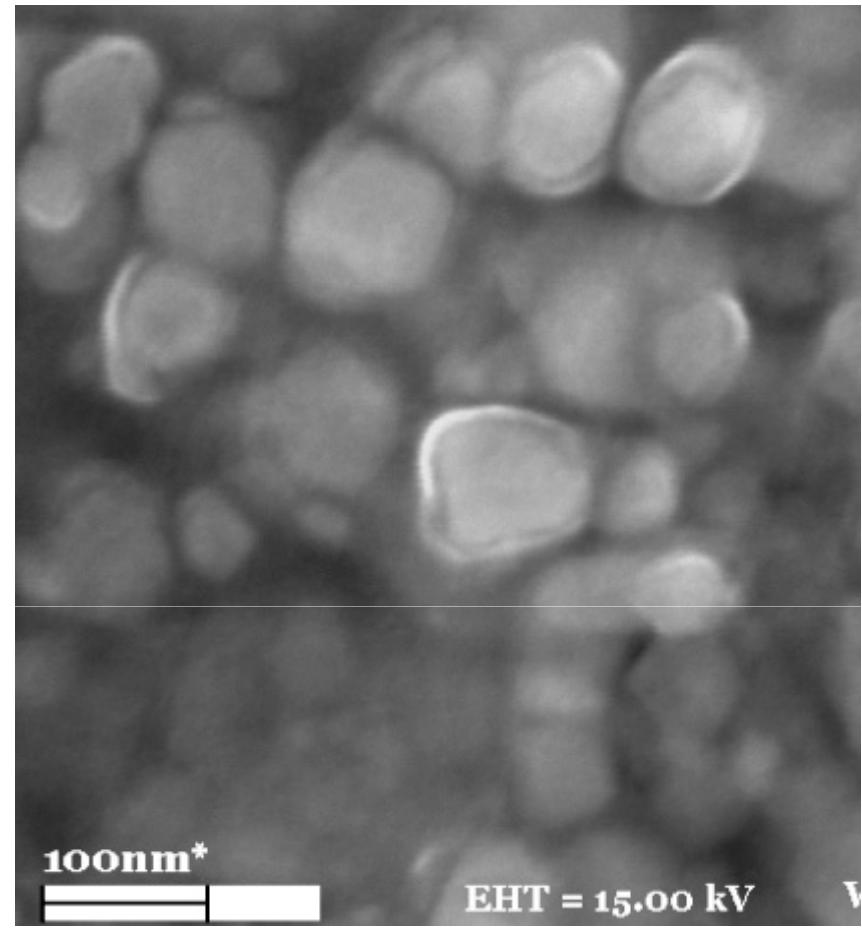
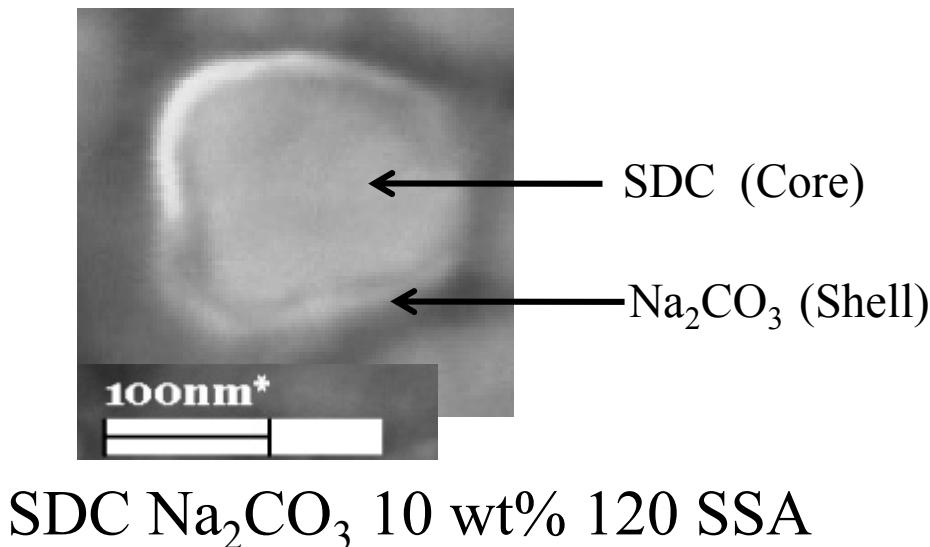
Methodology: in the composite at constant carbonate (10 wt% ratio), we control the total surface area amount of SDC, by controlling the SDC particles size with different specific surface areas (SSA)

SSA 11.1 m²/mg, crystallite size of 0.2μm-1.4 μm (Micron)

SSA 225 m²/mg, crystallite size of 5nm-10nm (Nano)

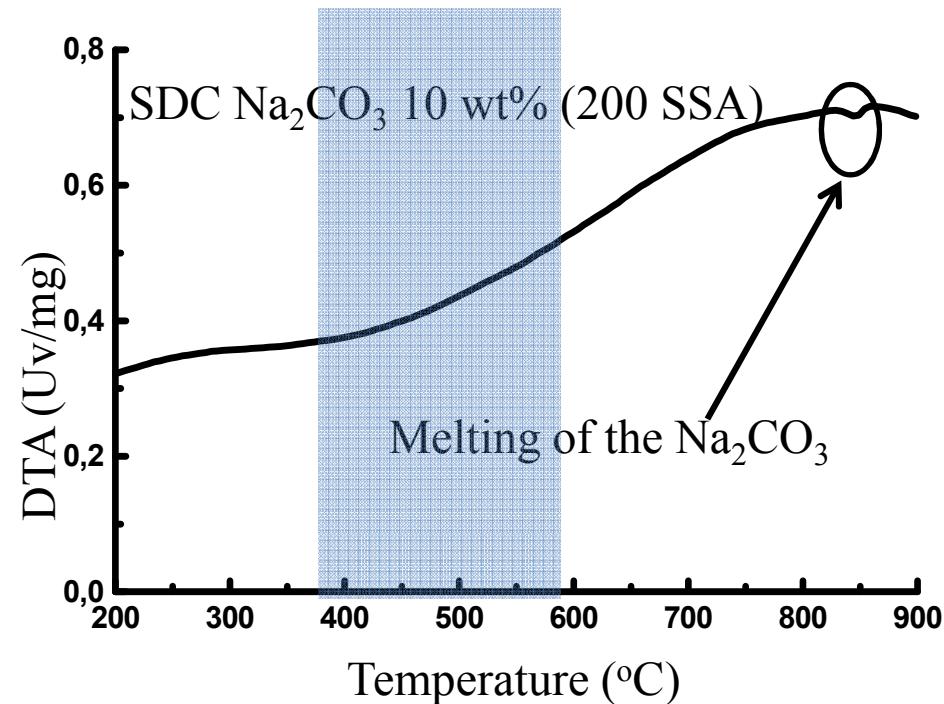
Weight ratio of micron sized /Nano sized SDC	Only ;micron sized	1.41	1.00	0.54	Only Nano sized
Specific surface area (m ² /mg) ²	50	100	118	150	220

3. Results: Cross Section SEM reveals core-shell structure

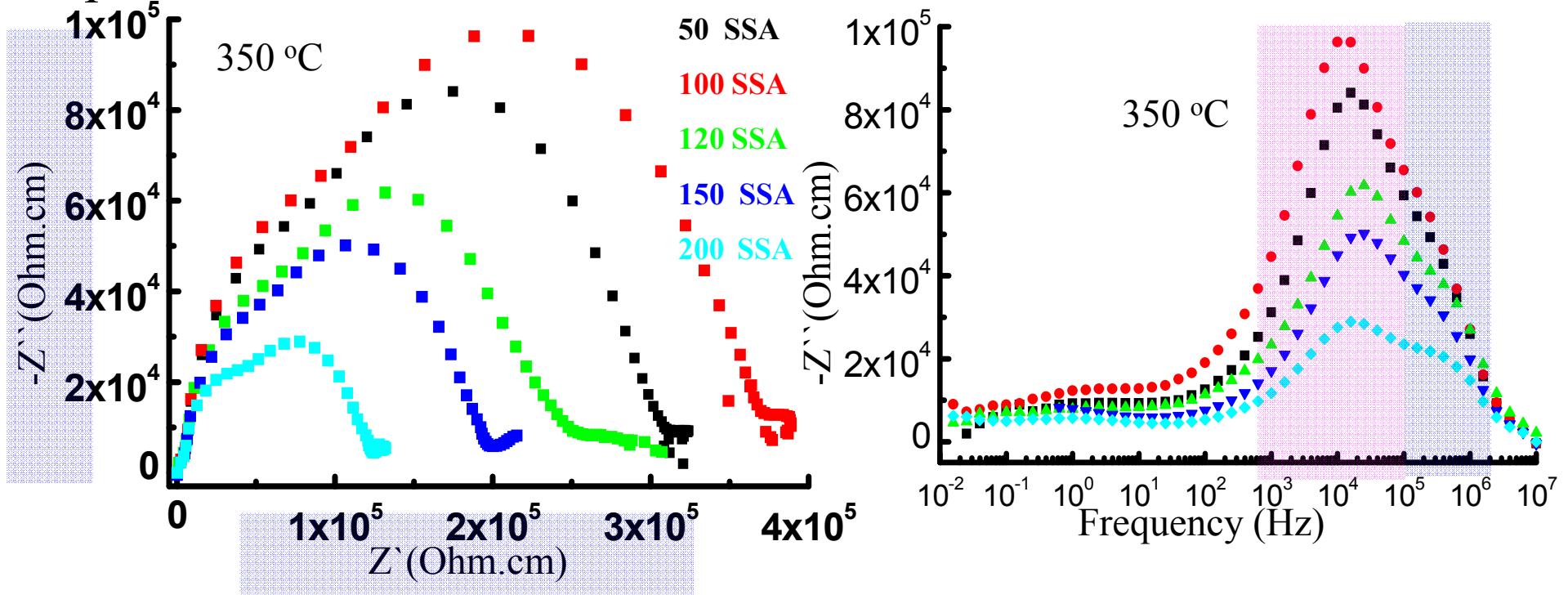


The Na₂CO₃ homogeneously covers the surface of the SDC particles and forms a core-shell structure. Presence of Na₂CO₃ helps SDC sinter at moderately low temperature and form dense electrolyte.

3. Results: stable microstructure at temperatures of interest

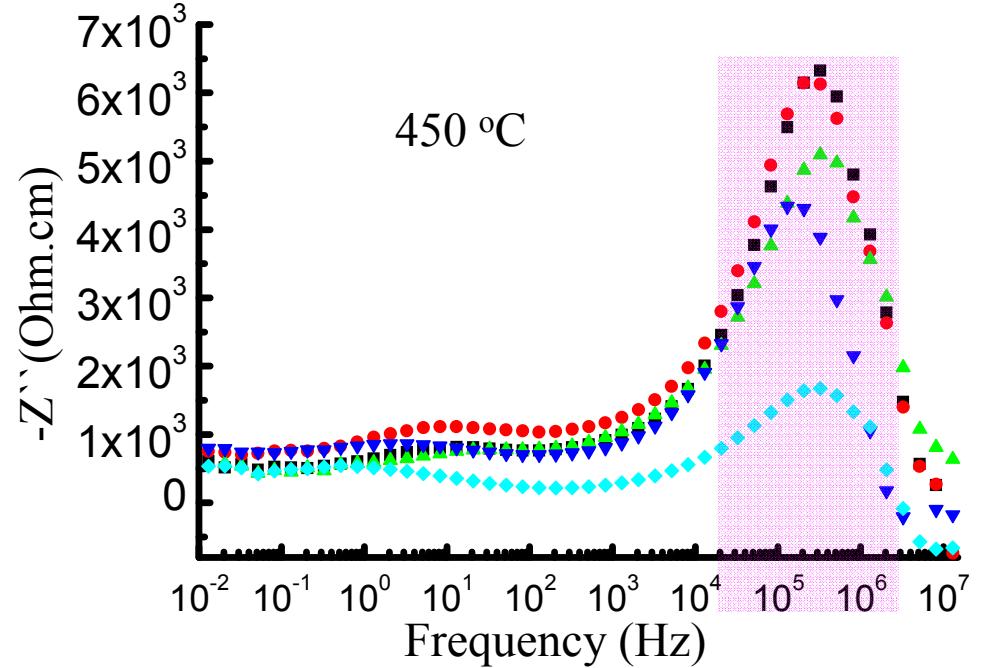
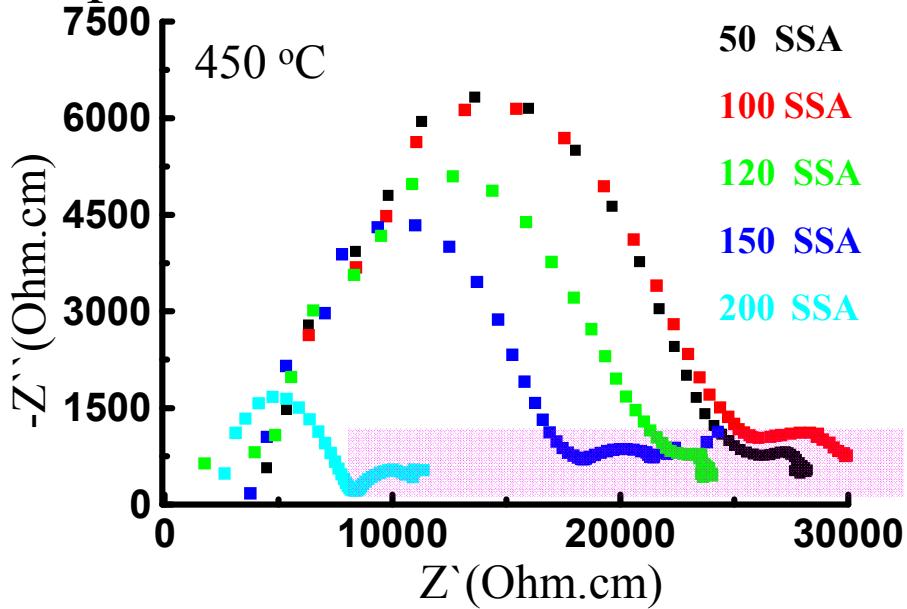


3. Isothermal Nyquist Plots: increase total surface area, decrease impedance



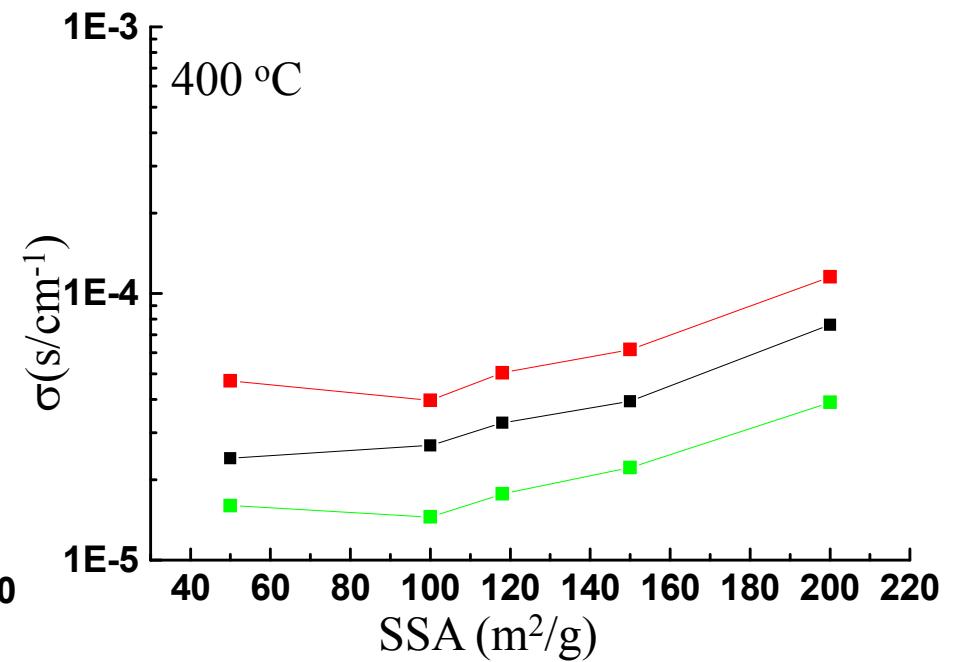
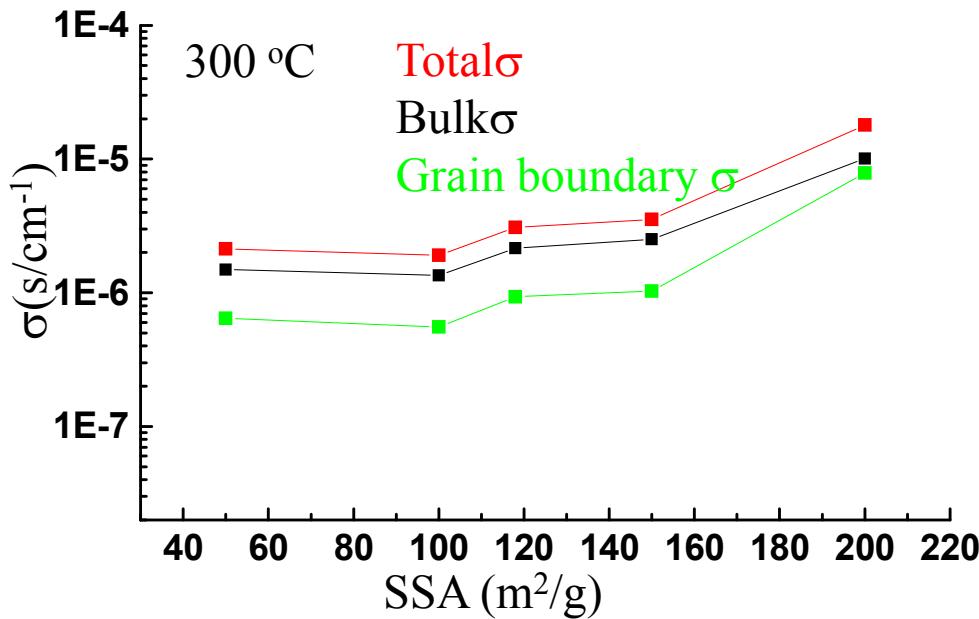
- Increased total surface area amount effectively reduce the total resistance.
- Nyquist plot of the composite shows overlapped the bulk and grain boundary semi circles.
- Broad spectroscopic plot confirms that 2 conduction mechanisms are present in the 10^7 - 10^3 Hz region.

3. Isothermal Nyquist Plots : increase total surface area, decrease impedance

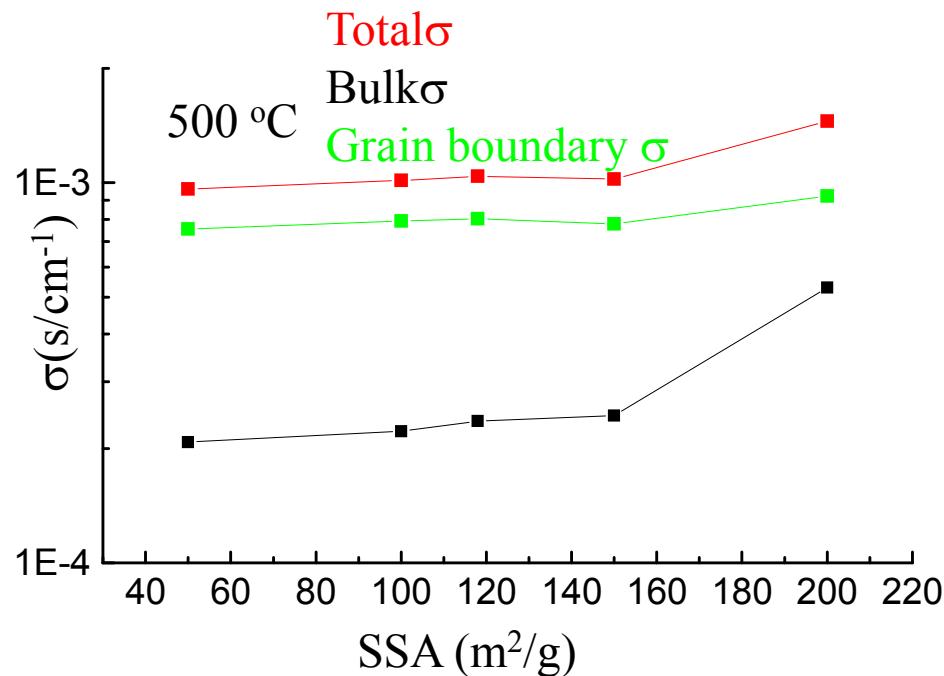


- Increased total surface area amount effectively reduce the total resistance.
- At $450\text{ }^{\circ}\text{C}$ the bulk and grain boundary contributions are more clearly distinguishable;
- Sharp peak at high frequency region of the Spectroscopic plot also confirm this observation.
- To summarize the trends over the temperature range...

3. Results: At lower temperatures, bulk dominates σ



4. Results: At 500 °C temperatures, grain boundary dominates σ



- Grain boundary dominated, it might be due to the interphase at 500 °C.

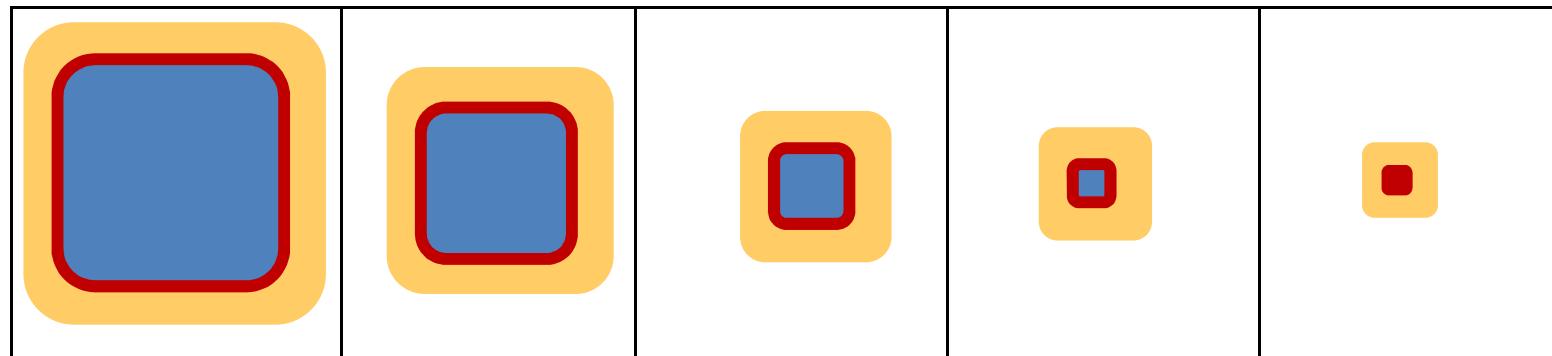
Weight ratio of micron sized /Nano sized SDC	Only micron sized	1.41	1.00	0.54	Only Nano sized
SSA (m^2/mg)	50	100	120	150	200
30.09.2012					

4. Model of particle morphology

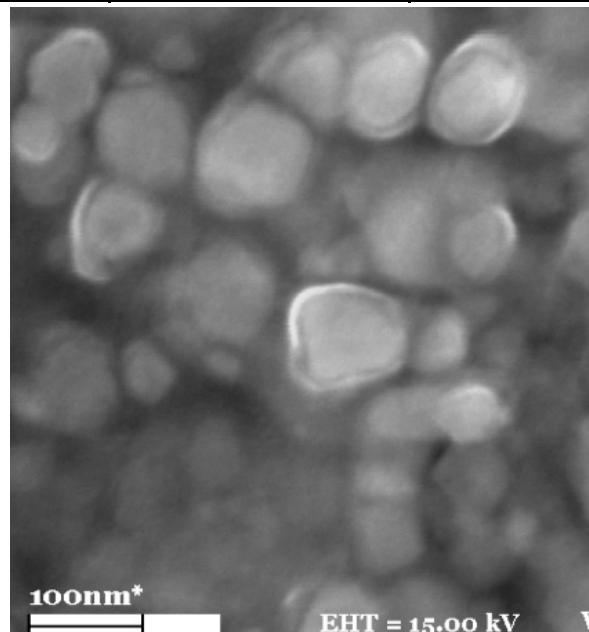
Na₂CO₃

Interface /Interphase

SDC

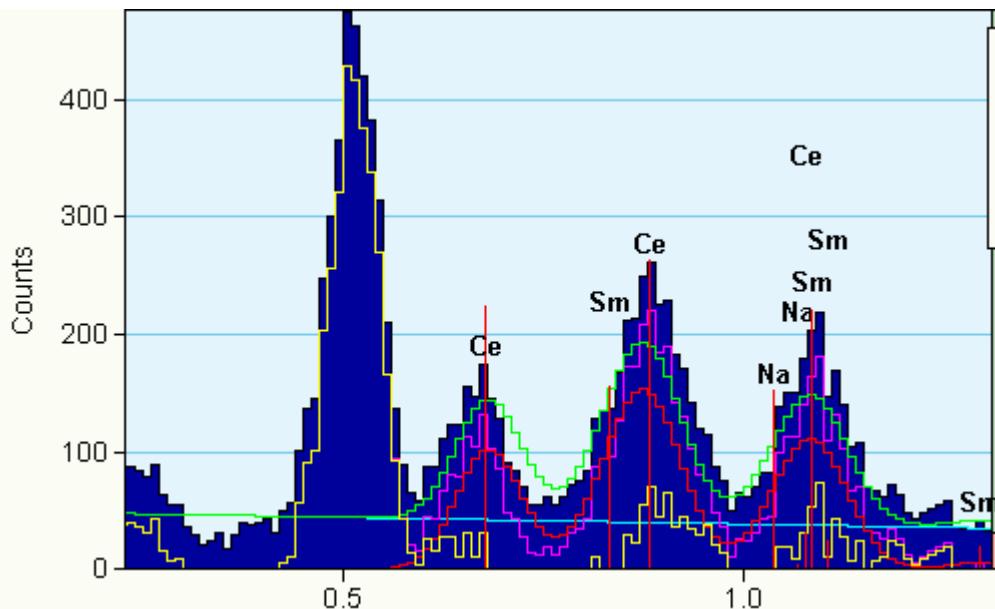


SSA	Micron sized SDC	100	120	150	Nano sized SDC
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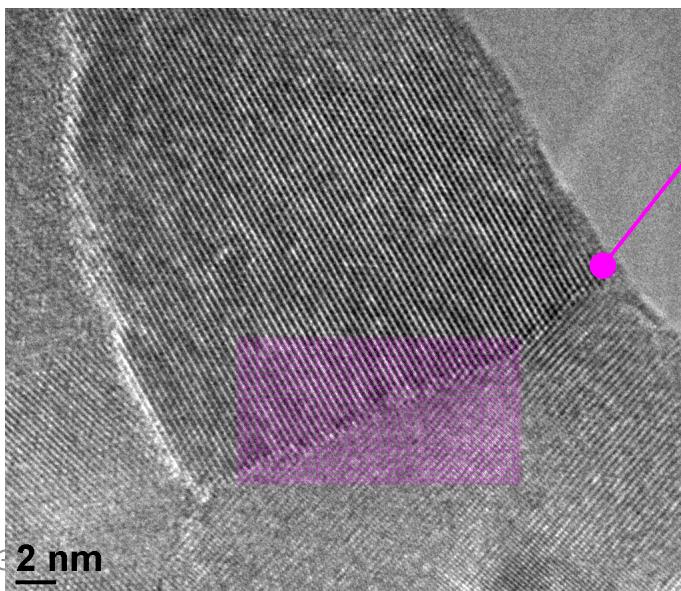
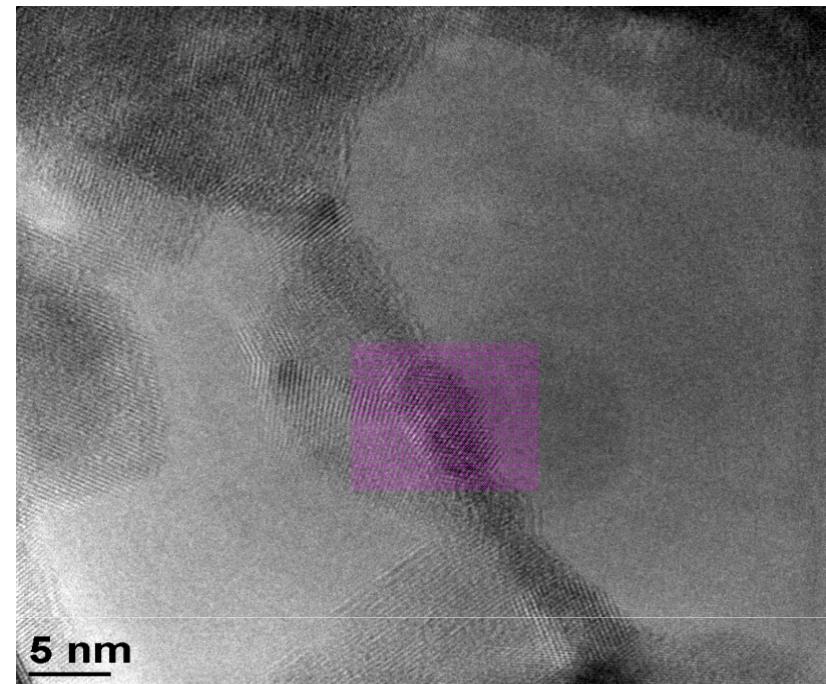


EDX analysis was performed on the nano sized composite to study the chemical composition.

4. TEM-EDX analysis on nano sized composite shows new phase



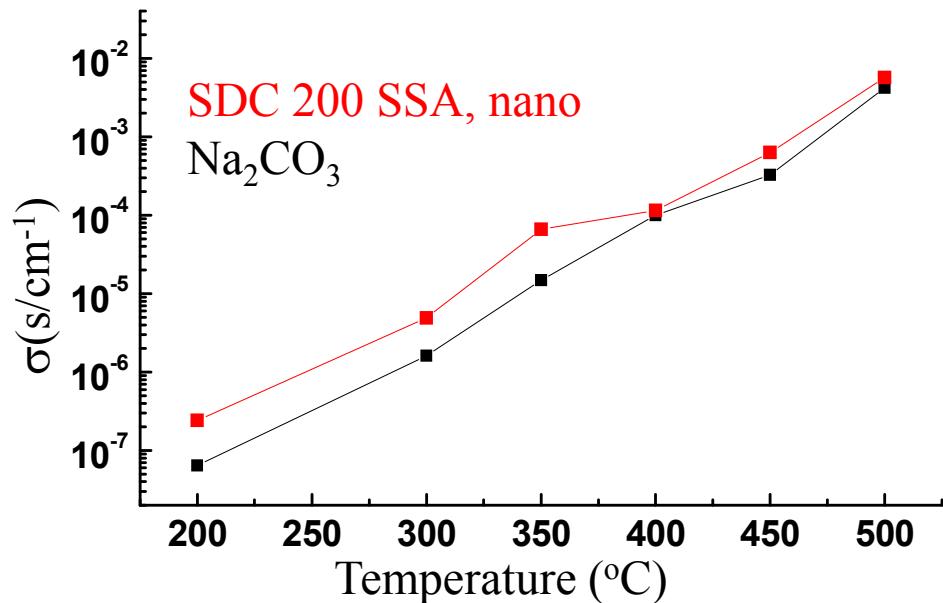
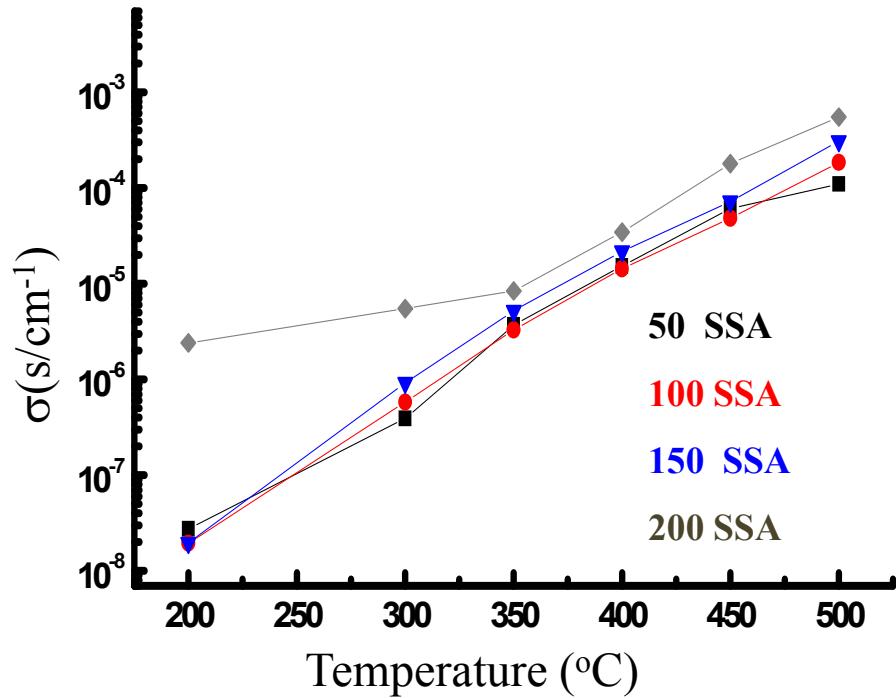
New interphase 5Na-SDC (5 wt% Na)



No Na containing new phase forming, between SDC particles.

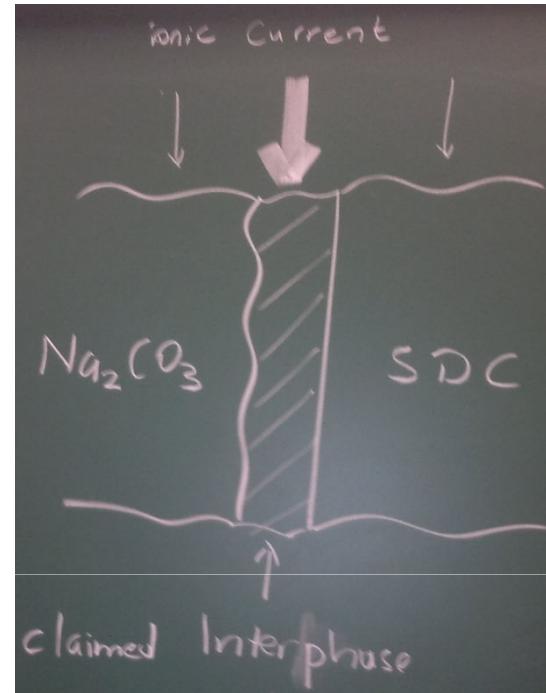
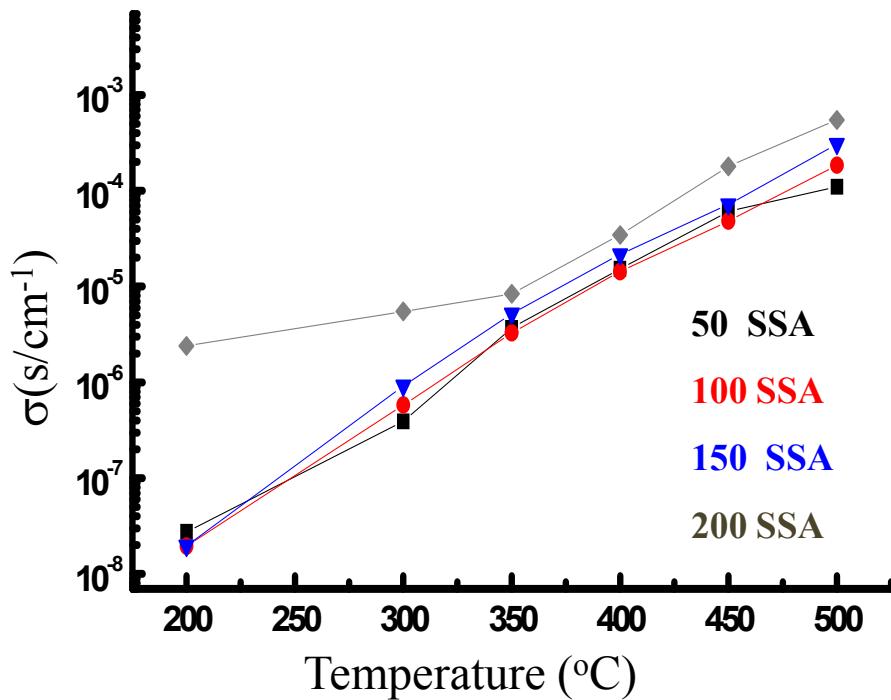
More TEM analysis on the system will be carried out to study the chemical composition of the interphase.

3. Results: Temperature Dependence of Conductivity



- Grain boundary consists of Na_2CO_3 and the interphase
- Which component determines the measured ionic conductivity?

3. Results: Temperature Dependence of Conductivity



- Interphase is believed to contribute to the ionic conductivity in 200-500 $^\circ\text{C}$ range significantly.

4. Summary

- Formation of the new (inter) phase was observed in nano sized SDC. This phase is believed to contribute to the ionic conductivity in 200-500°C range significantly.
- Amorphous Na_2CO_3 homogeneously cover the SDC and form core-shell structure by simple dry ball milling process.
- Impedance ionic conductivity is proportional to the increment of the surface area amount of SDC in the composite at constant carbonate amount.
- Further TEM analysis will be carried out on micron sized SDC Na_2CO_3 composite to study the chemical composition of the interphase.

3. Acknowledgement

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Davis, CA 95616.



TÜBİTAK

