Imperial College London

10 November 2017

3D imaging studies on electrochemical systems at Imperial College London

MANIFEST Researcher Workshop

Dami Taiwo, Vladimir Yufit, Farid Tariq, Enrique Ruiz-Trejo, Antonio Bertei, Kristina Maria Kareh, Ann Huang, Barun Chakrabarti, Moshiel Biton, Sam Cooper, Nigel P. Brandon

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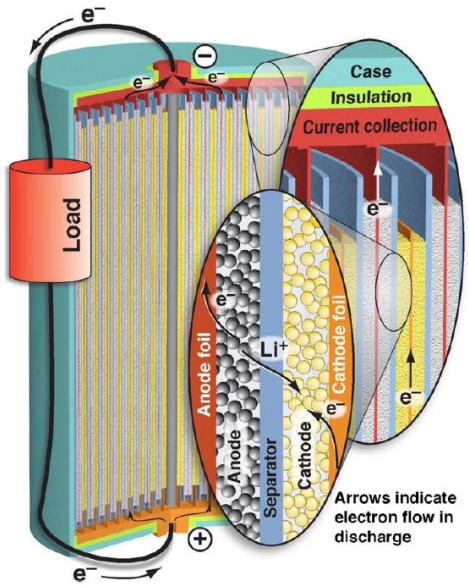
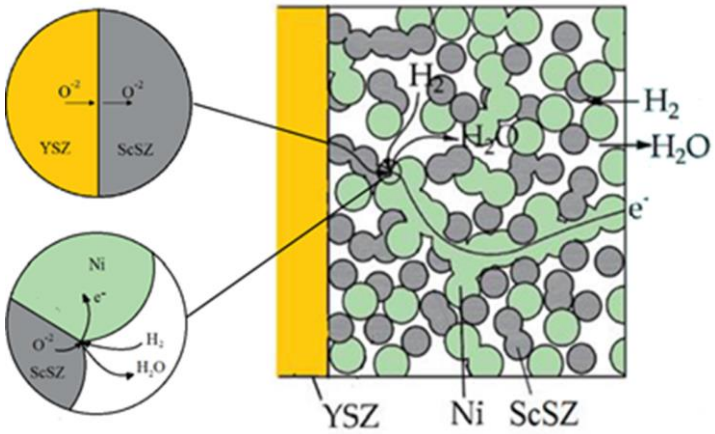
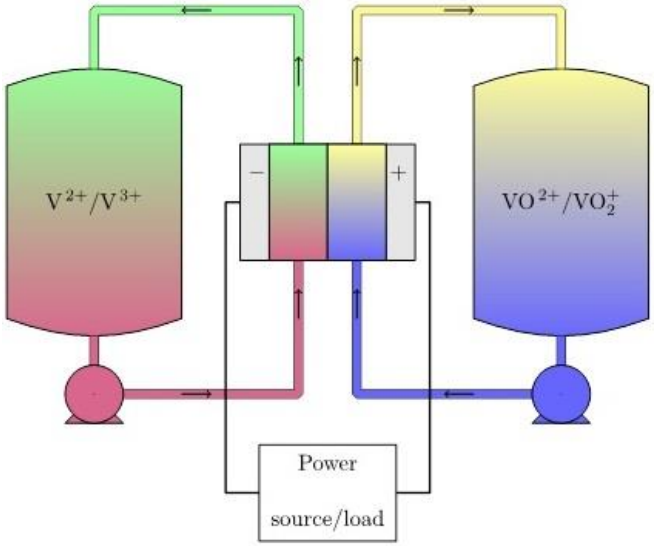
Batteries and fuel cells







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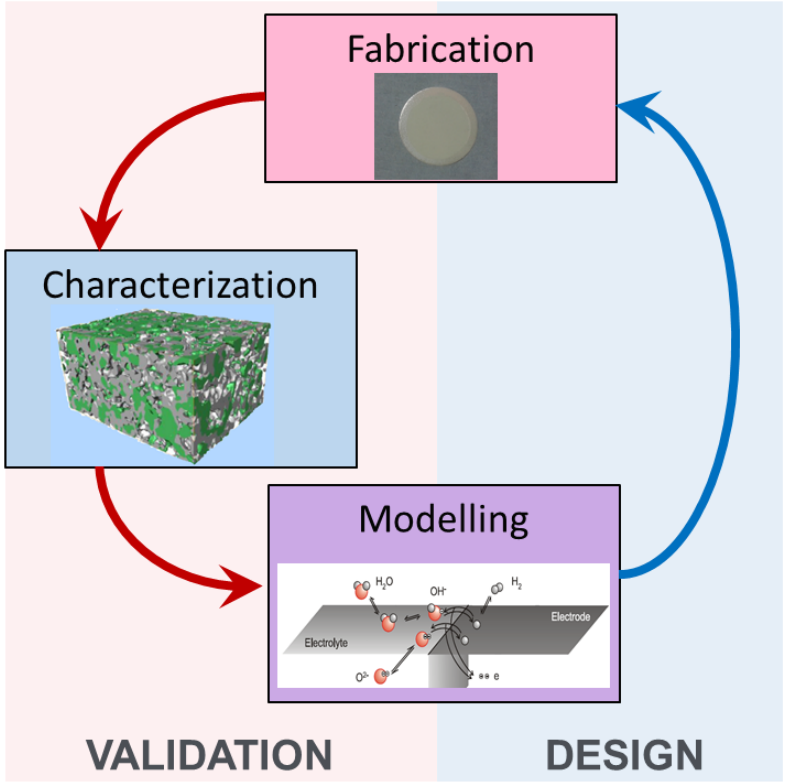
Model-based design approach



Electrode microstructure for

Performance optimisation ↓

Bulk properties
- volume fractions
- connectivity
- area per unit volume

Degradation ↓

Local hot spots
Structural evolution

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3D Imaging Facilities

- **Lab X-ray CT*** unit with high-efficiency flat panel detector.
- Up to **1 µm** spatial resolution.
- Capability to incorporate in-situ rigs for dynamic experiments.

- Access to **FIB-SEM tomography** equipment.
- High spatial resolution (<10 nm for FIB imaging).
- Better suited for nanostructured material analysis.

*From energy storage capital grant : EPSRC Capital for Great Technologies call - Grid-Scale Energy Storage

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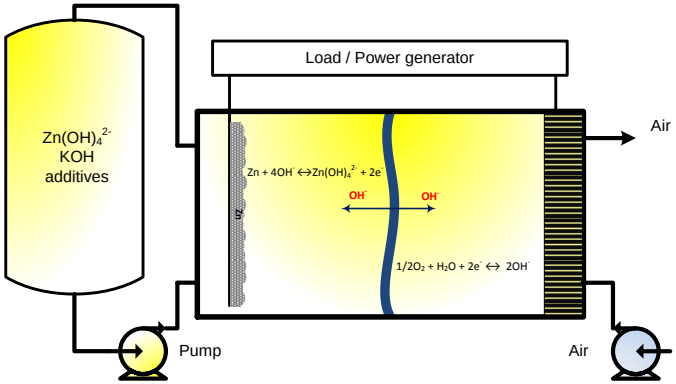
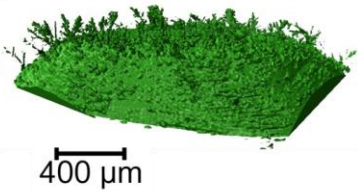
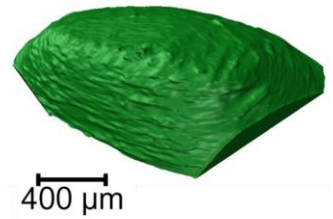
Zinc-based flow batteries – Morphological degradation of Zn

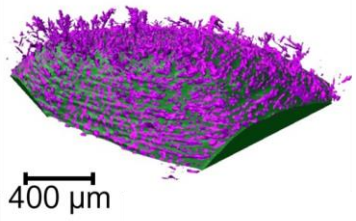




Zinc tip as deposited

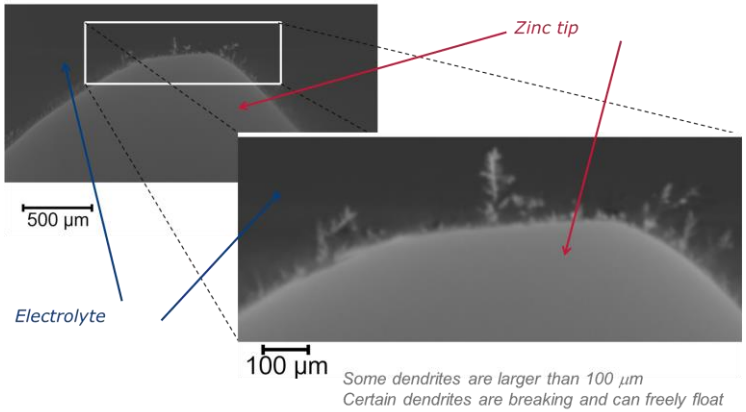


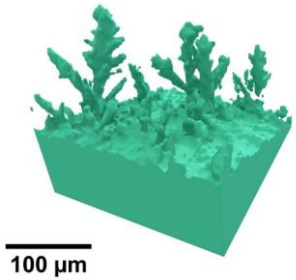
Bare zinc tip before deposition

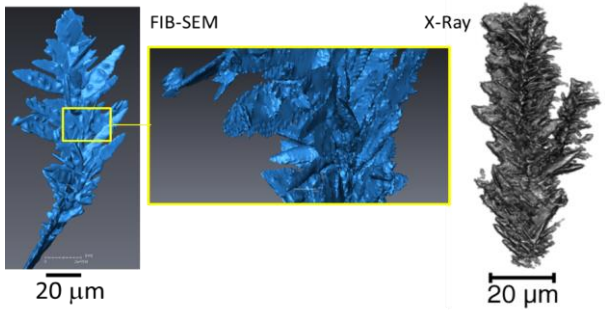


Zinc tip with dendrites "emphasized"

Surface area of the bare tip	Surface area of the tip with dendrites	Surface increase ratio
$4.43*10^6$ µm²	$6.31*10^6$ µm²	1.42







Zn dendrite formation during the first charge

M. Biton,F. Tariq,V. Yufit, Z. Chen,N. Brandon, *Acta Materialia* **2017**, *141*, 39-46

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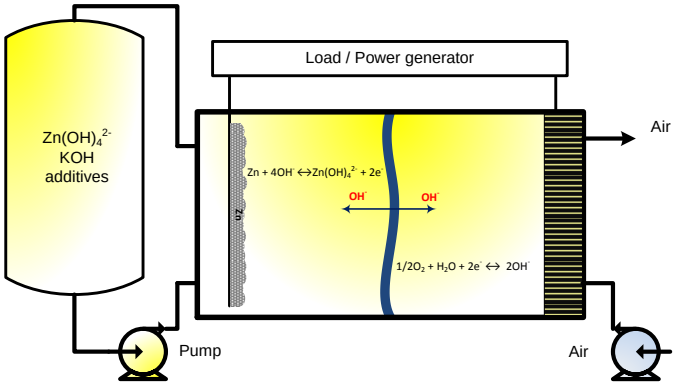
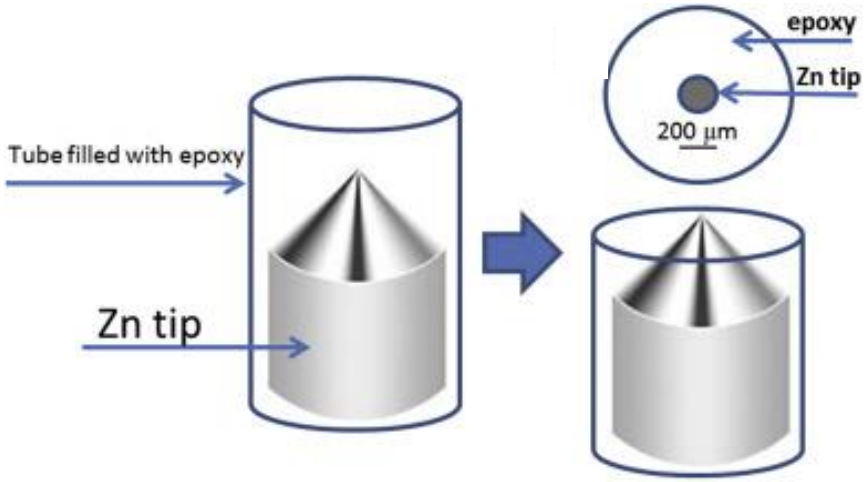
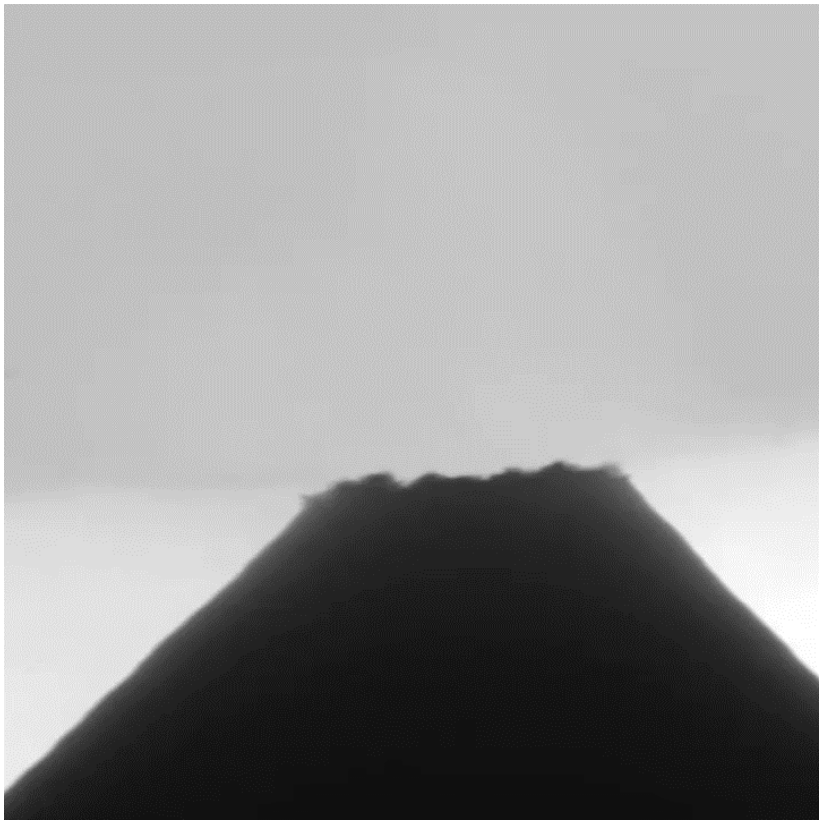
Zinc-based flow batteries – Morphological degradation of Zn





In-situ observation of Zn dendritic growth



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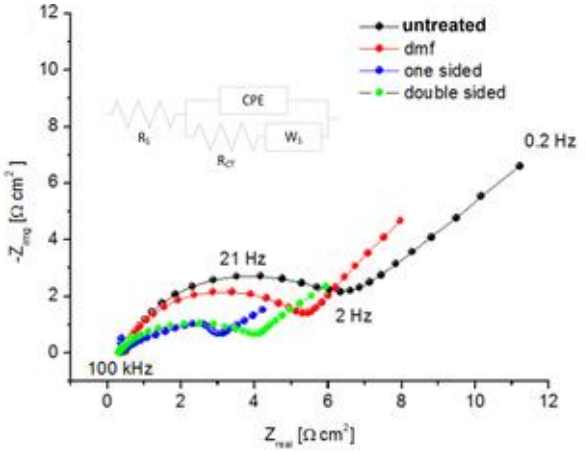
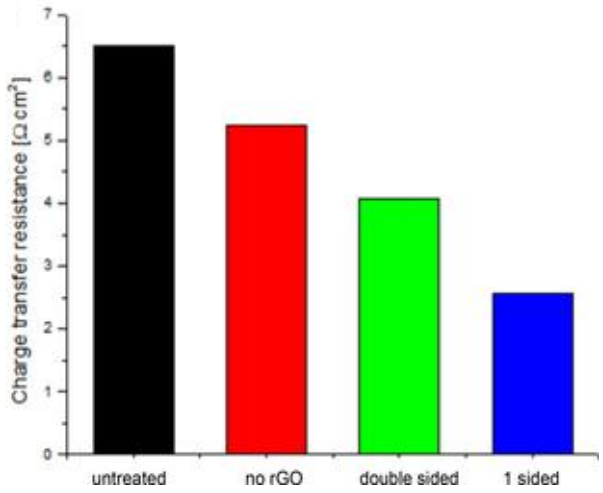
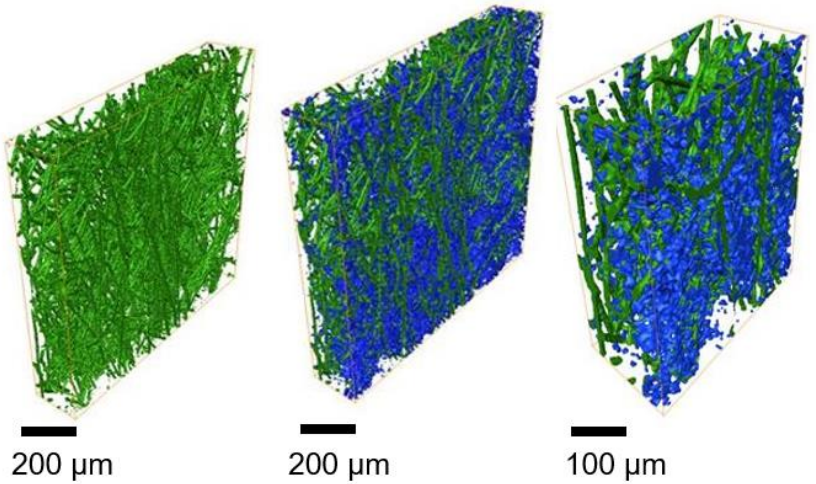
Vanadium redox flow batteries – Carbon paper modification





No rGO Single side rGO Double side rGO



	Total specific surface area with XCT [µm² µm⁻³]	BET specific surface area [µm² µm⁻³]
Untreated CP	**0.81**	**2.8**
One-sided	**1.01**	**5.1**
Double sided	**1.11**	**11.1**

B. Chakrabarti, D. Nir, V. Yufit, F. Tariq, J. Rubio-Garcia, R. Maher, A. Kucernak, P. Aravind, N. Brandon, *ChemElectroChem* **2017**, *4*, 194.

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Lithium-ion batteries – Thick electrodes with controlled porosity

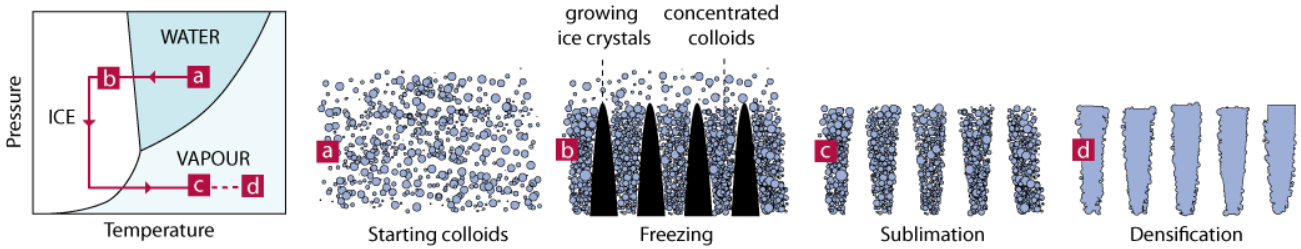
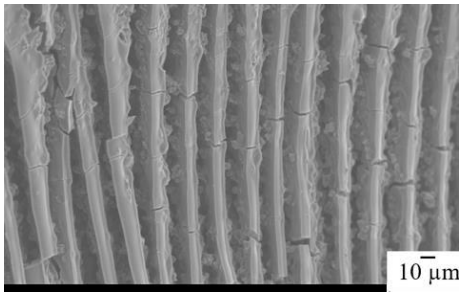


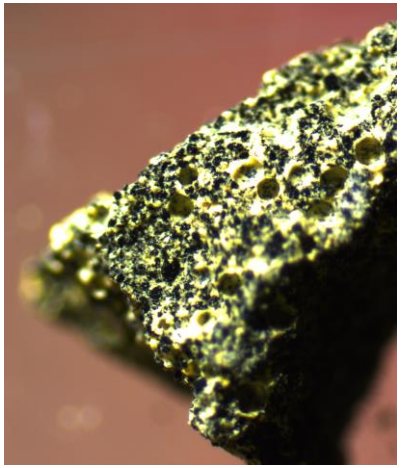
Image ref: Deville, S., Ice templating of porous materials

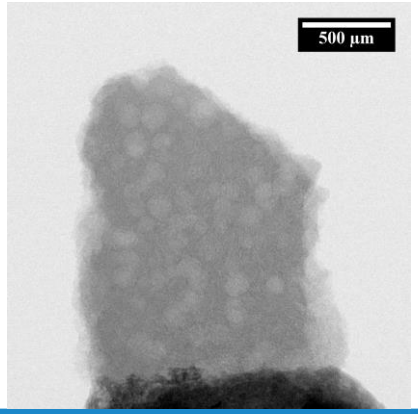
- ***In collaboration with Prof. P. Grant and Dr. A. Huang (Oxford)***
- ***Manufacture of thick high energy density electrodes***
- ***Improve battery power through microstructure control***

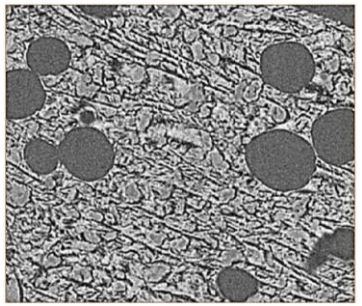


Cross section SEM

Si/SiO$_X$







X-ray µCT

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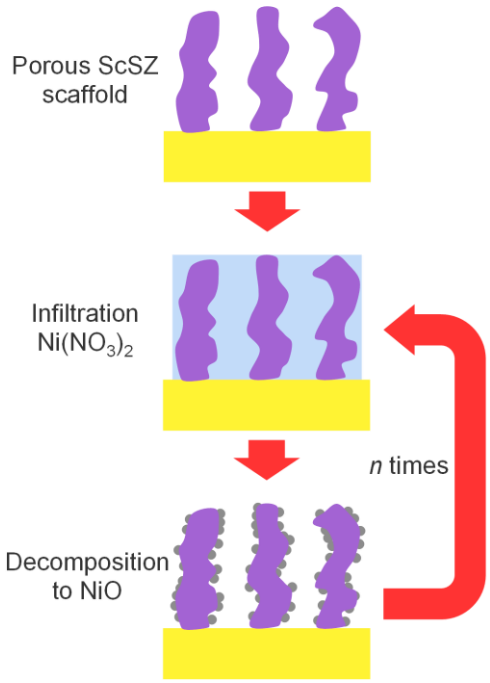
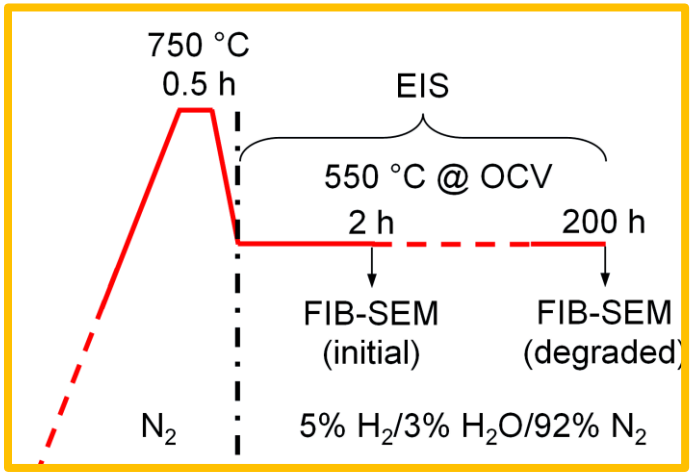
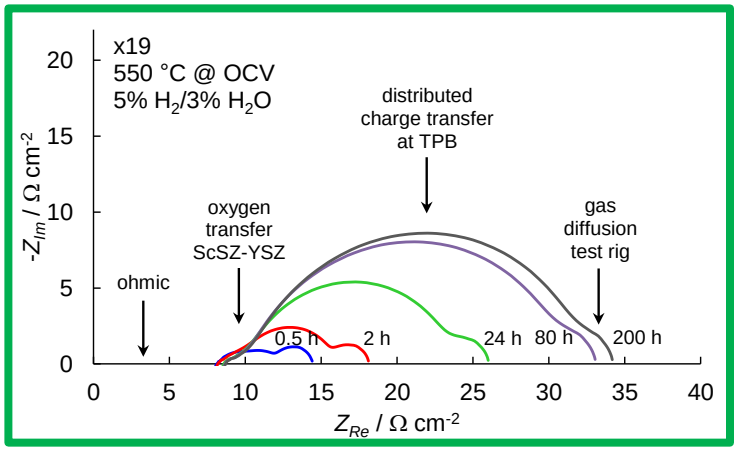
Solid Oxide Fuel Cells – Microstructural degradation in NiScSZ

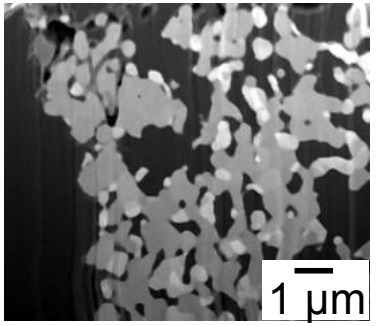




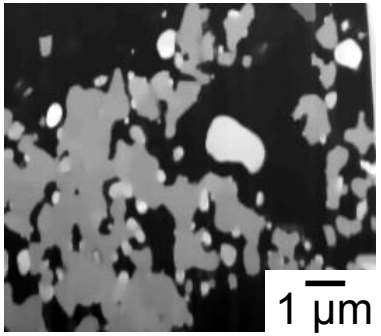


FIB-SEM

Initial anode



Degraded anode



A.Bertei, E.Ruiz-Trejo, K.Kareh, V.Yufit, X.Wang, F.Tariq, N.P.Brandon, *Nano Energy* **2017**, *36*, 526-536

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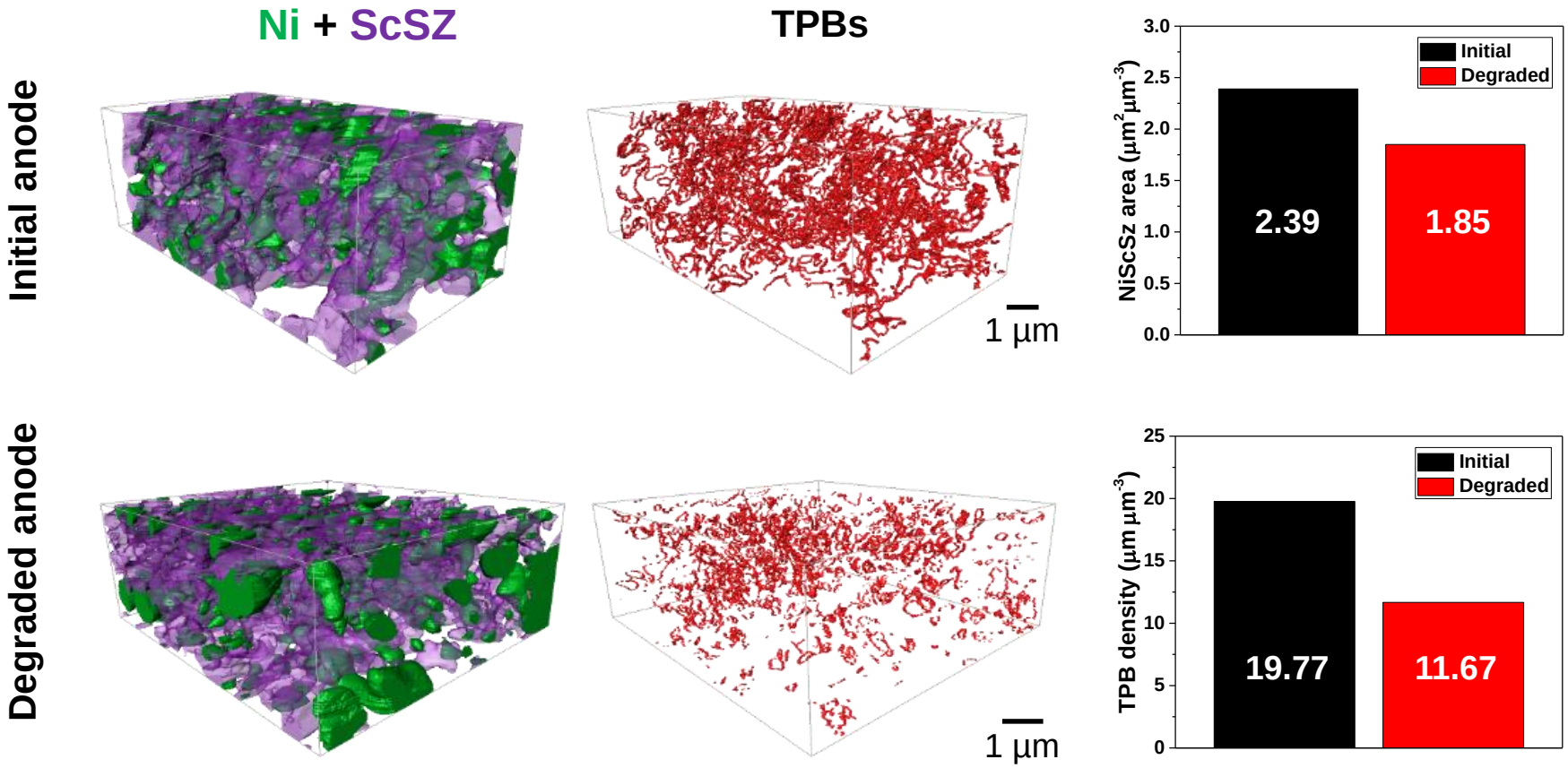

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Thanks to..

Vladimir Yufit

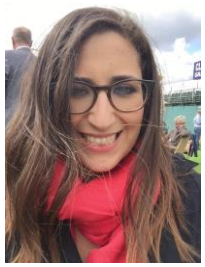
Farid Tariq

Sam Cooper

Enrique Ruiz-Trejo

Antonio Bertei

Moshiel Biton



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