## Southampton



#### Self-assembly of lithium batteries with 3D architecture

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#### Microbatteries

#### Broadly speaking 1-10 mm<sup>2</sup>

Intended applications include....

- Ink jet printer cartridges
- Micro accelerometers
- Micro transmitters
- Implantable medical devices
- etc ...

Pulse power, short periods of high power usage between longer periods of 'idle' operation, is a requirement of many of these devices



The microbattery electrode design is based on the 6.8 mm x 1.3 mm coin cell





### Planar thin film $\rightarrow$ 3D





#### **Fabrication of 3D-MBs**

Successive depositions of active materials (current collector, electrode, electrolyte, 2<sup>nd</sup> electrode, current collector) on 3D substrate

	100 ppi	100 ppi compressed to 20 %	
	Act V Spot Magn Def WD Esp 200 pm	Acc.Y. Spot Magn. Def. WD. Esp. 200 pm	
Thickness of foam/	Surface Area Gain		
mm			
0.8	4	28	
2	10	70	
5	25	180	
10	50	350	



#### Scope

- Cathodes
  - Electrodeposition of MnO<sub>2</sub>
  - Spin-coating of LiFePO<sub>4</sub>
- Polymer electrolytes
  - Electrodeposition
  - Solvent evaporation
- Completing the cell

#### **Electrodeposition of MnO<sub>2</sub>**

0.3 MnSO<sub>4</sub> in 0.3 H<sub>2</sub>SO<sub>4</sub> at 5 mA cm<sup>-2</sup> at 95 °C, followed by annealing at 400 °C for 10 hr

#### Ti or RVC substrate





#### **Conformal deposition of MnO<sub>2</sub>**



#### Half cells assembled: Li | 1 M LiPF<sub>6</sub> in 1:1 EC/DMC | MnO<sub>2</sub>/RVC





#### Area gain effect and rate testing





#### **Spincoating LiFePO**<sub>4</sub>



Bare



5 %



10 %

75% LiFePO₄, 20% CB, 5% PVDF-HFP Varying wt% solids in CP







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# Electrochemical performance



## Multiple coatings of LiFePO<sub>4</sub>



Bare



1 Spin



-sse-

2 Spins



**3** Spins



4 Spins





Comparison
with a
conventional
LiFePO₄
electrode

	Slow rate capacity/ µA h cm <sup>-2</sup>	Rate for 50% DoD
Convential 60 µm Composite Pellet	1.3	~9C
3D RVC LFP electrode 3 coats	1.1	~25 C 12



15% v/v PEGDA (M<sub>n</sub> ~700) in PC, 0.5 M LiTFSI supporting electrolyte Deposited on Cu<sub>2</sub>Sb on Au/Cr EQCM substrate at 100 mV s<sup>-1</sup> between -0.5 V and -3.0 V vs Ag wire over 25 cycles



NiSn | polymer | Li

#### Planar half cell

Deposition solution: 0.5 M LiTFSI in: 15% v/v PEGDA (containing 10% w/w nano-SiO<sub>2</sub>), 4% v/v PEGMEA in PC



"Charge transfer resistance" – probably due to SEI on NiSn surface -SSe-



#### **Deposition onto RVC**

**Combined Ag wire** reference & Pt mesh counter electrode (2 mm diameter)

Syringe needle to Ar gas supply

~ 1 mL deposition solution

RVC substrate fixed by epoxy resin

Ti foil contact to substrate

#### SEM





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