



Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research



Electrochemical Performance of Materials with high interest in lithium-ion batteries prepared by Pulsed Laser Deposition

EMRS 2016 SPRING MEETING

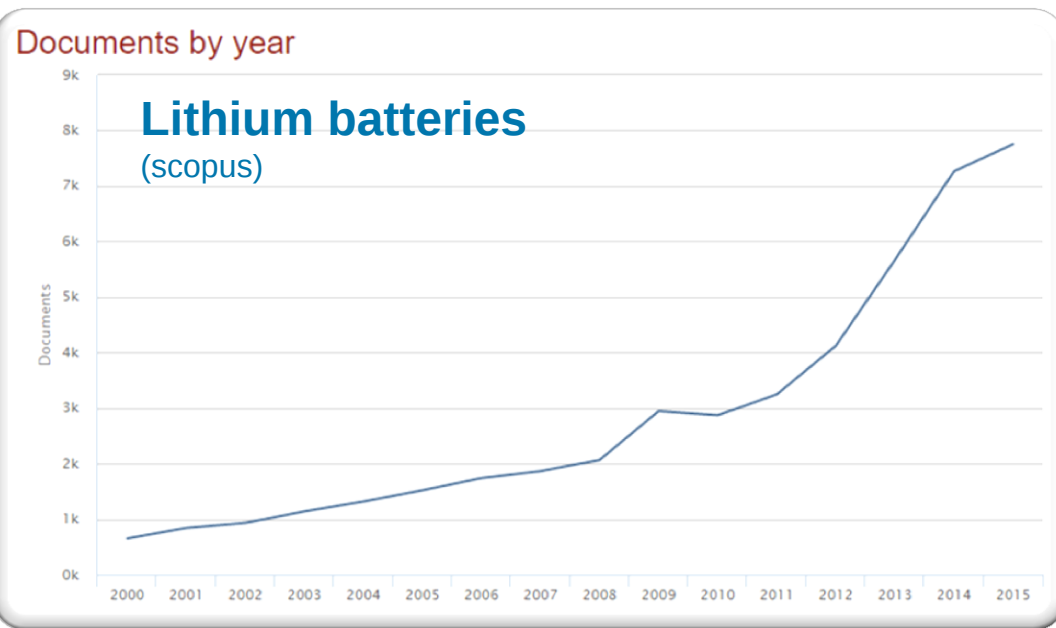
Lille, 2-6 May 2016

Rafael Trócoli, Alex Morata, Markus Fehse, Edgar Ventosa and Albert Tarancón

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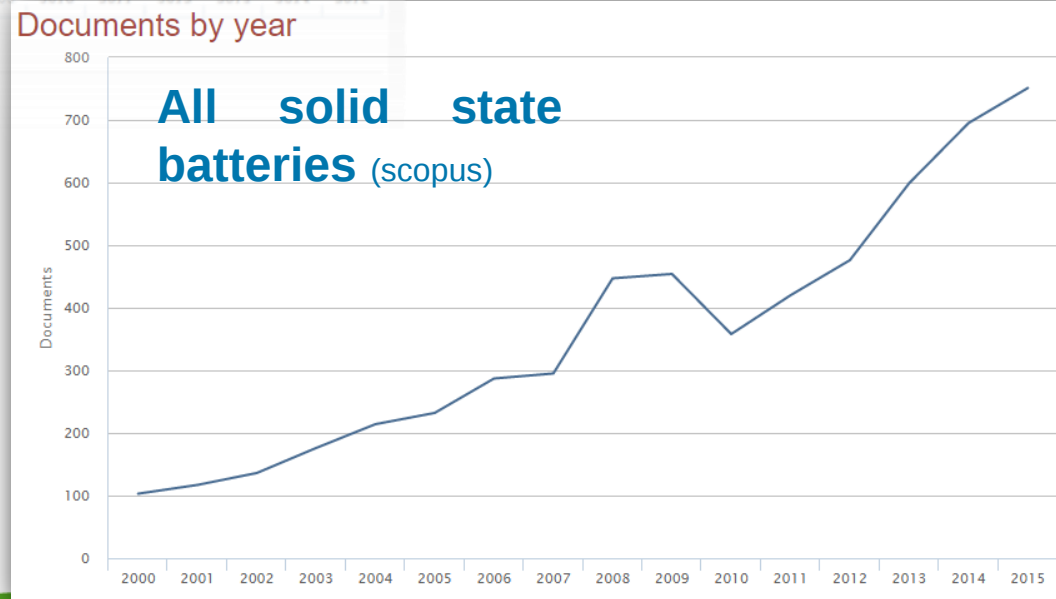
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- **Objectives**
- **PLD-Deposition conditions**
 - Combinatorial vs single target
 - O2 pressure, temperature...
- **Structural characterization optimized thin film**
 - X-ray diffraction
 - Scanning electron microscopy
 - AFM
- **Electrochemical characterization**
 - Cyclic Voltammetric study
 - Rate capability
 - Cycling stability

INTRODUCTION

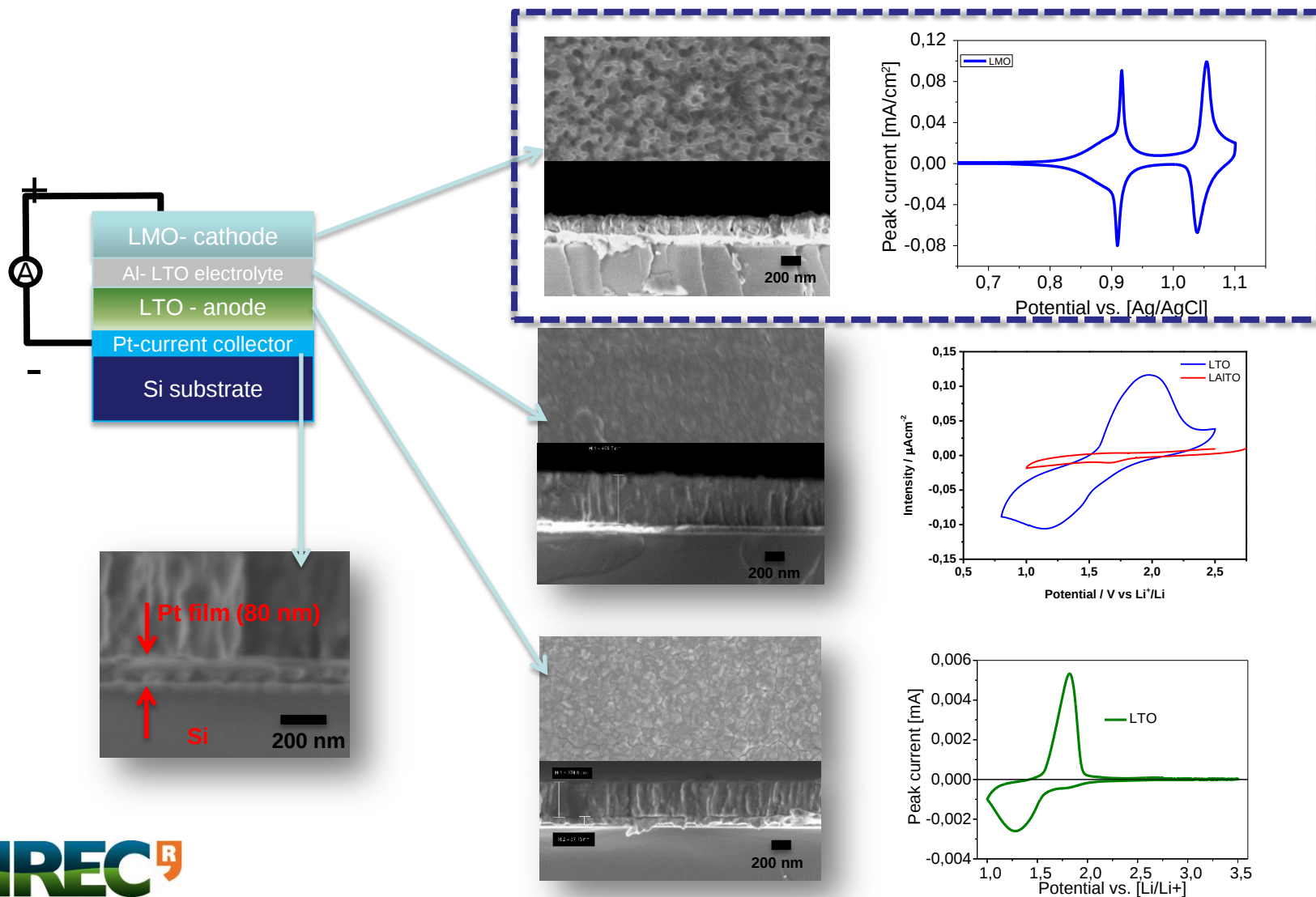


8000 publications
on 2015

750 publications
on 2015



OBJECTIVE: Full battery based on SPINEL materials



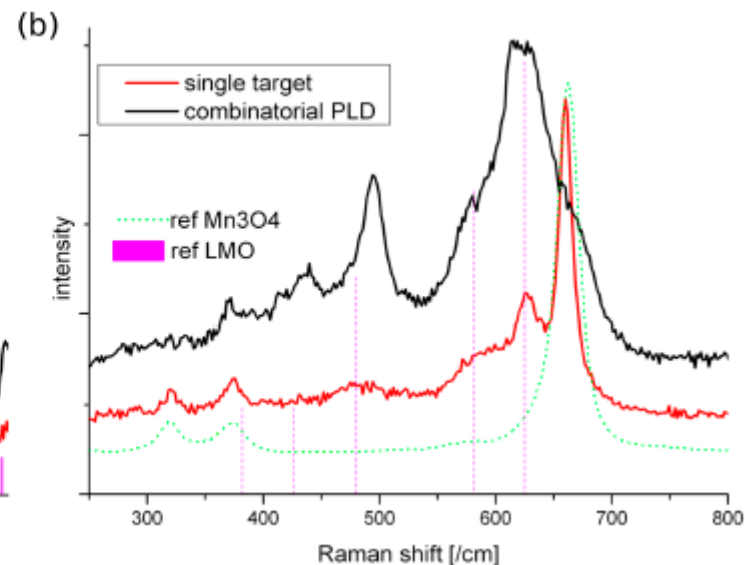
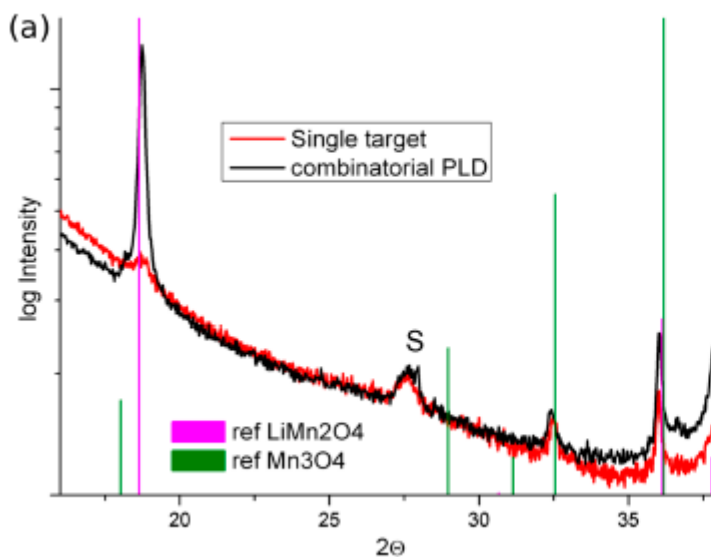
Deposition of LiMn_2O_4 (LMO) by PLD

Single target
 LiMn_2O_4

Combinatorial
 $\text{LiMn}_2\text{O}_4 + \text{Li}_2\text{O}$

X-ray

RAMAN



Combinatorial: mayoritary Spinel LiMn_2O_4

Single target: low Spinel LiMn_2O_4

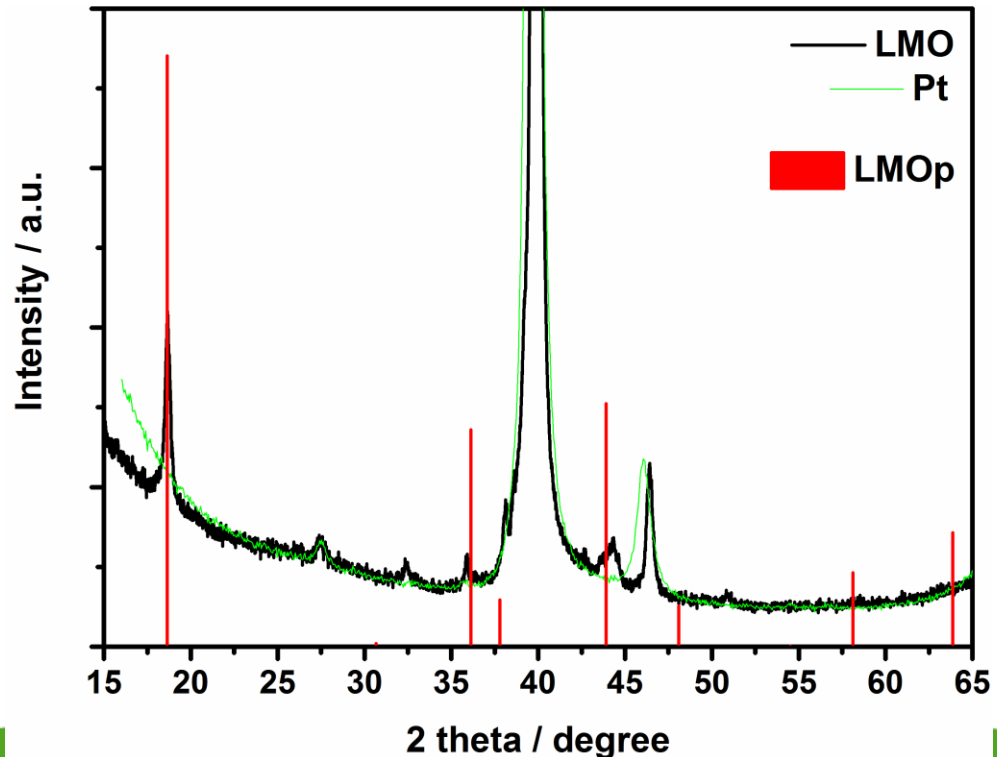
Deposition of LiMn_2O_4 by PLD

Combinatorial
 $\text{LiMn}_2\text{O}_4 + \text{Li}_2\text{O}$

Fluency (mJ/cm^2)	Frecuency (Hz)	O_2 pressure (mT)	Temperature ($^\circ\text{C}$)	Pulses (k)
650	10	20	650	x(800 LMO + 400 Li_2O)

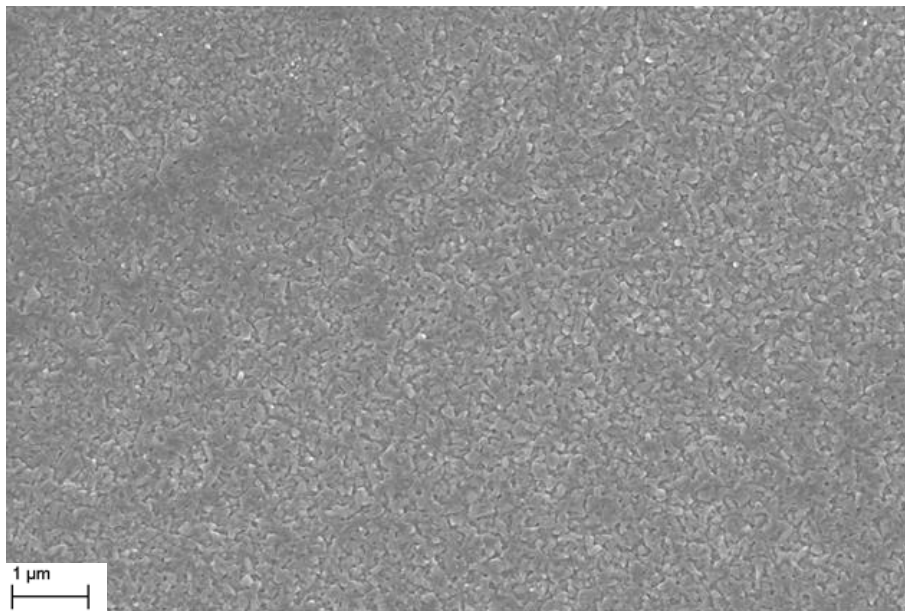
Pure spinel LiMn_2O_4

Preferable orientation (111)

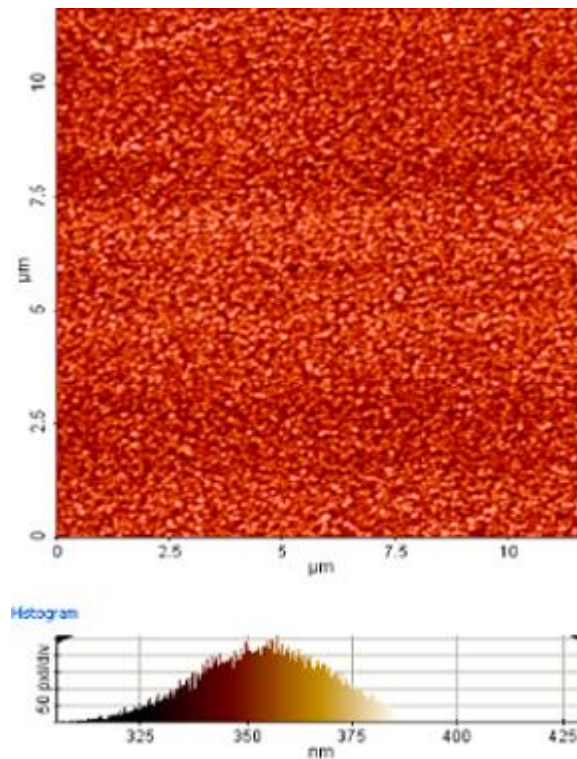


Structural characterization of LiMn_2O_4 thin film

SEM



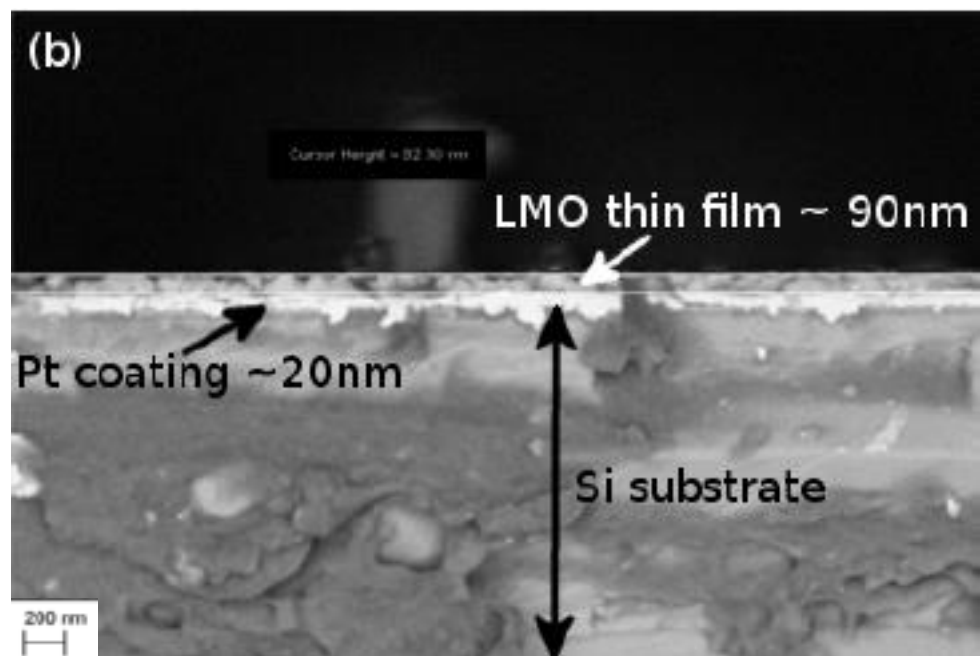
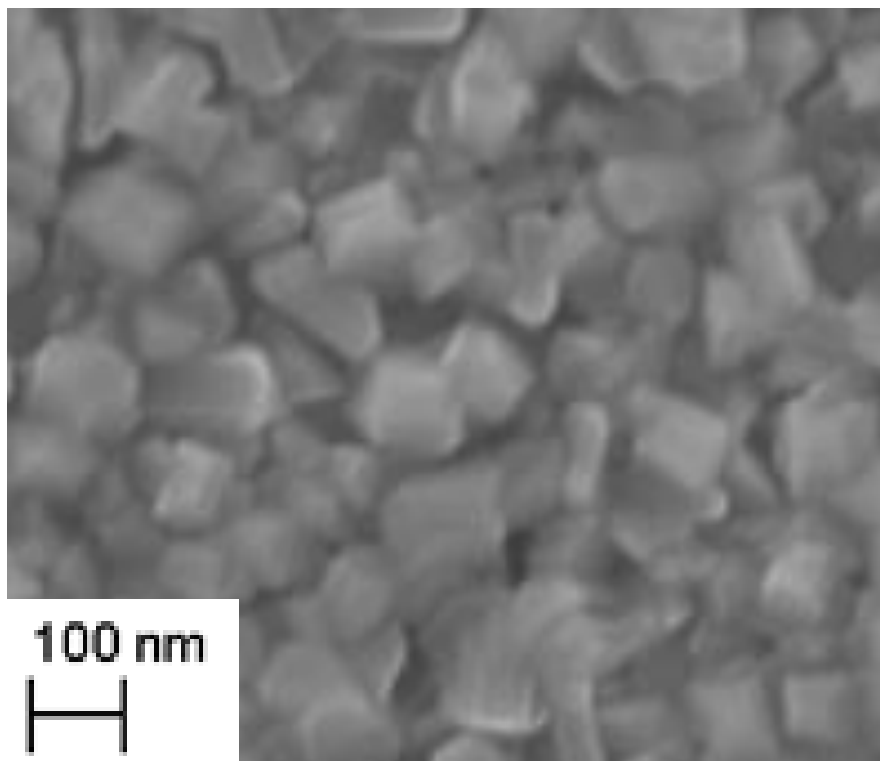
AFM



$R_q \approx 12\text{ nm}$

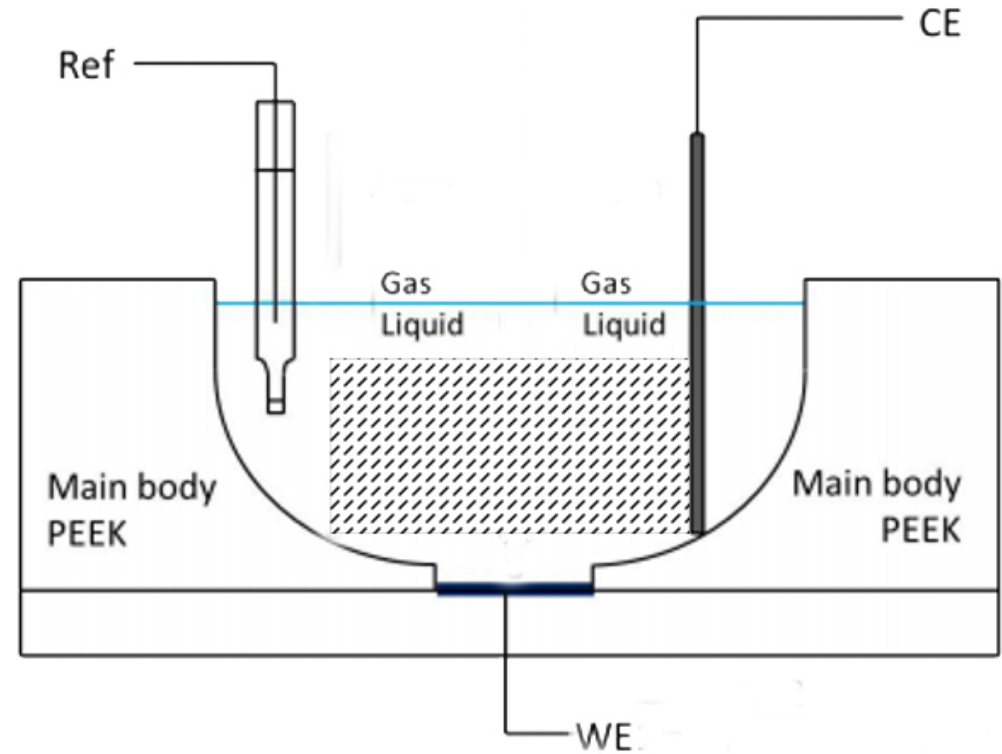
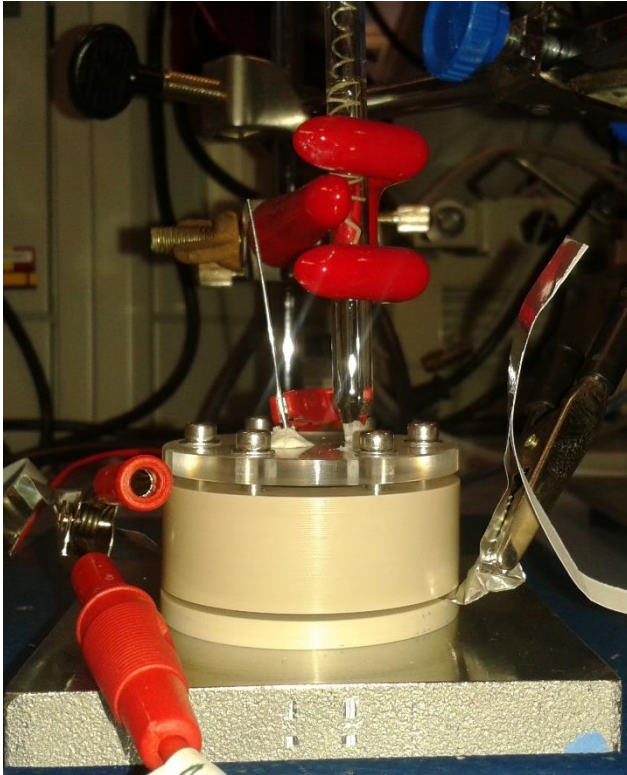
Structural characterization of LiMn_2O_4 thin film

SEM



Electrochemical characterization of LiMn_2O_4 thin film

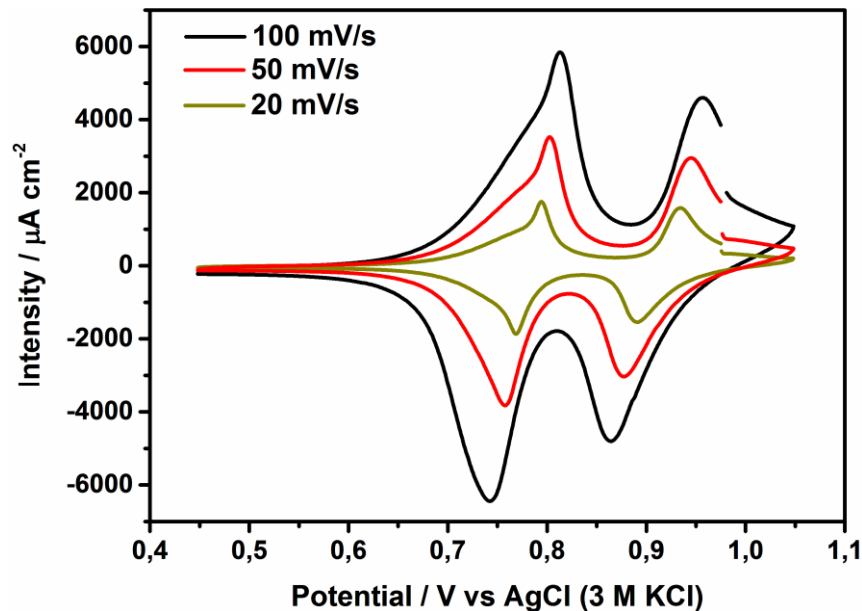
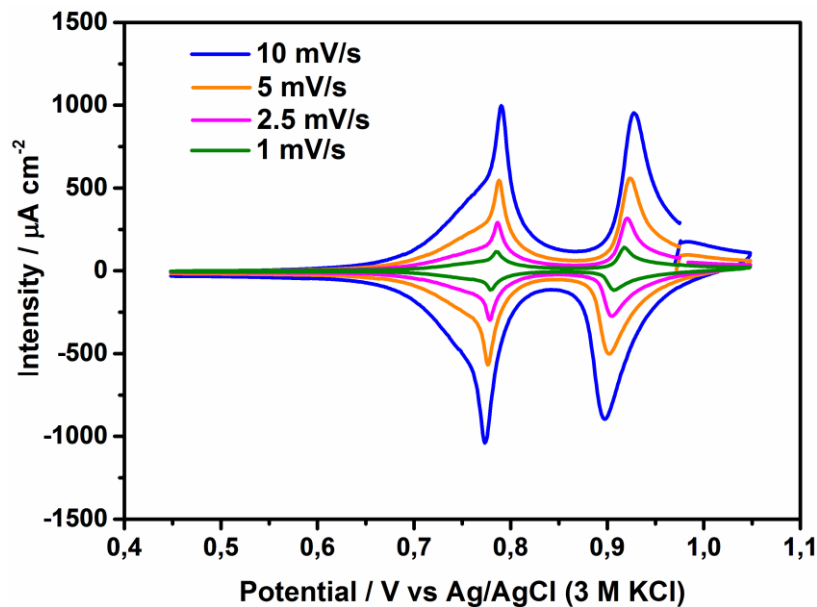
Electrochemical cell



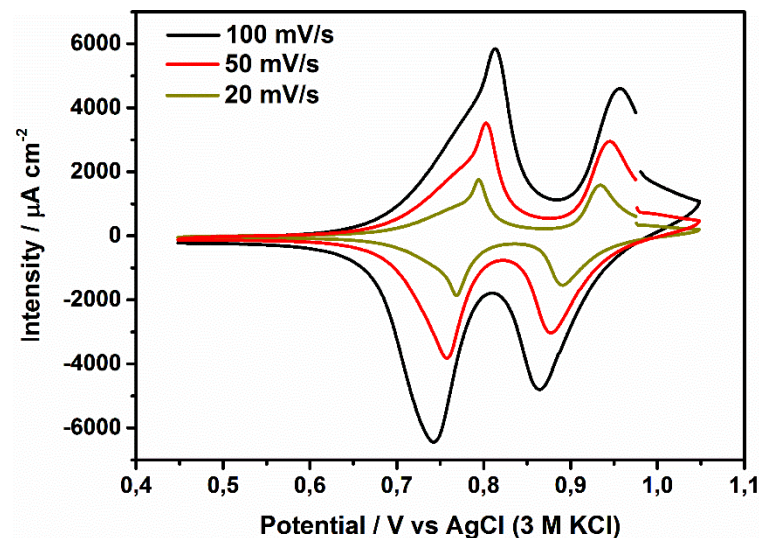
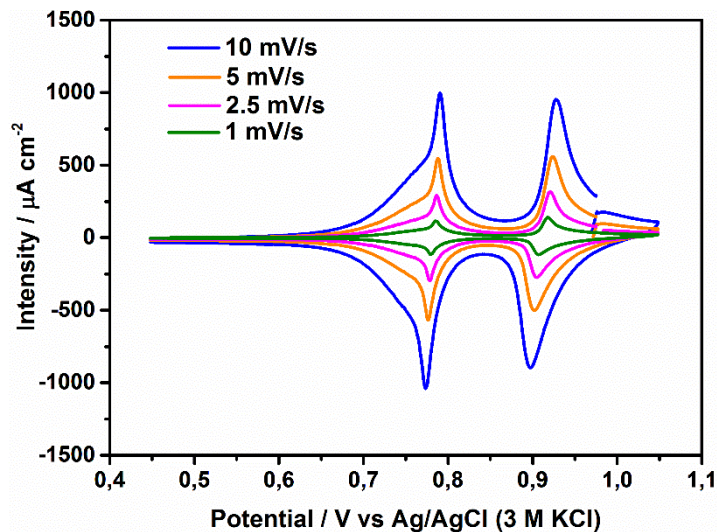
Electrolyte = 1 M Li_2SO_4

Electrochemical characterization of LiMn_2O_4 thin film

Cyclic Voltammetry



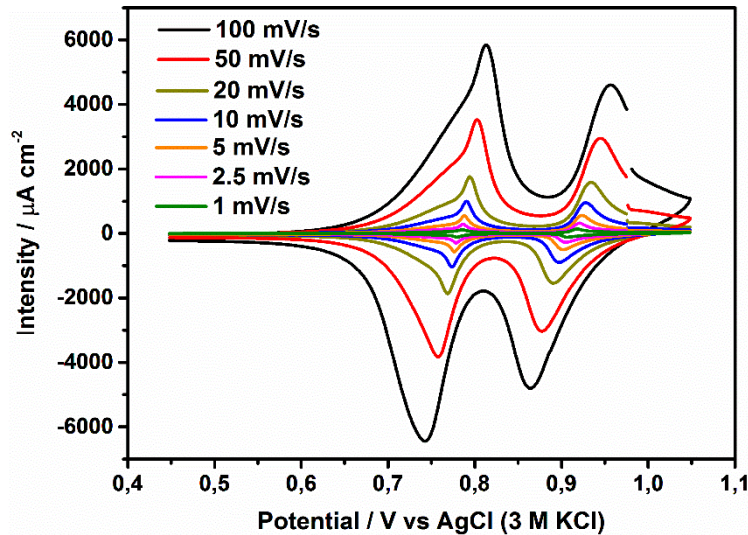
Electrochemical characterization of LiMn_2O_4 thin film



	Scan rate (mV /s)			
	1	2.5	5	10
$\Delta E_{\text{Oxi}_1/\text{Red}_1}$ (mV)	6	8	11	17
$I_{\text{Oxi}_1}/I_{\text{Red}_1}$	0.952	0.977	0.977	0.957
$\Delta E_{\text{Oxi}_2/\text{Red}_2}$ (mV)	11	16	22	31
$I_{\text{Oxi}_2}/I_{\text{Red}_2}$	1.1	1.1	1.1	1.05

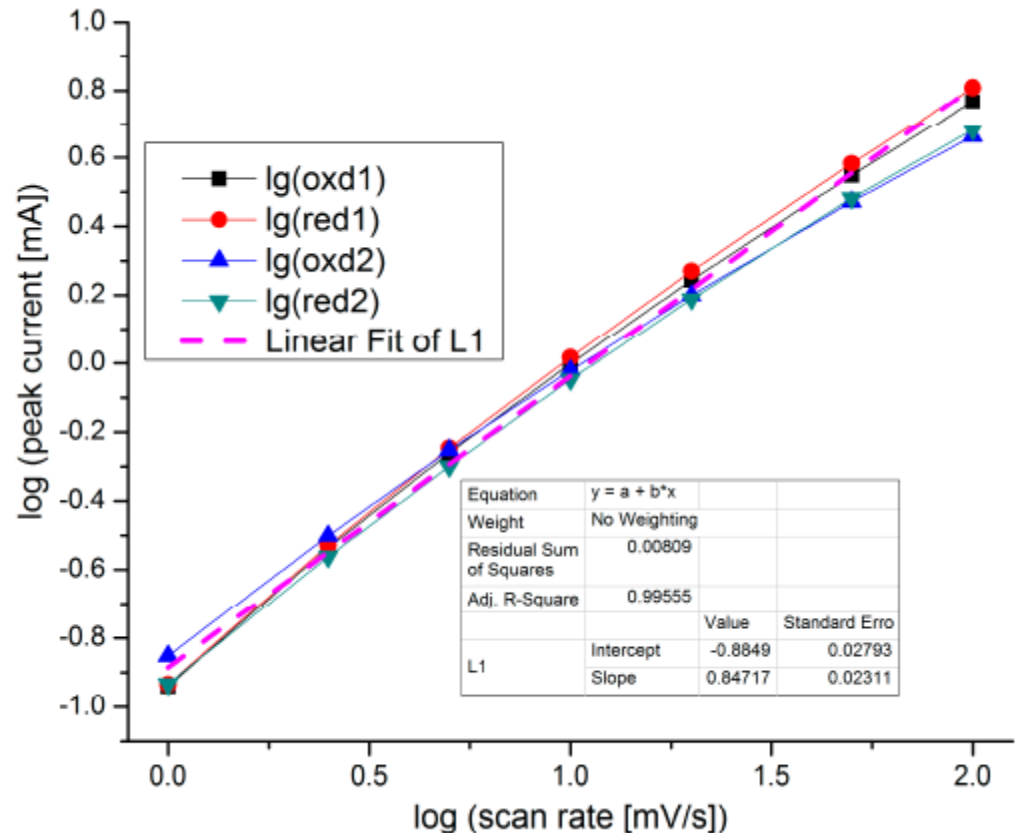
	Scan rate (mV /s)		
	20	50	100
$\Delta E_{\text{Oxi}_1/\text{Red}_1}$ (mV)	25	44	70
$I_{\text{Oxi}_1}/I_{\text{Red}_1}$	0.96	0.93	0.92
$\Delta E_{\text{Oxi}_2/\text{Red}_2}$ (mV)	43	68	92
$I_{\text{Oxi}_2}/I_{\text{Red}_2}$	1.02	0.98	0.96

Electrochemical characterization of LiMn_2O_4 thin film



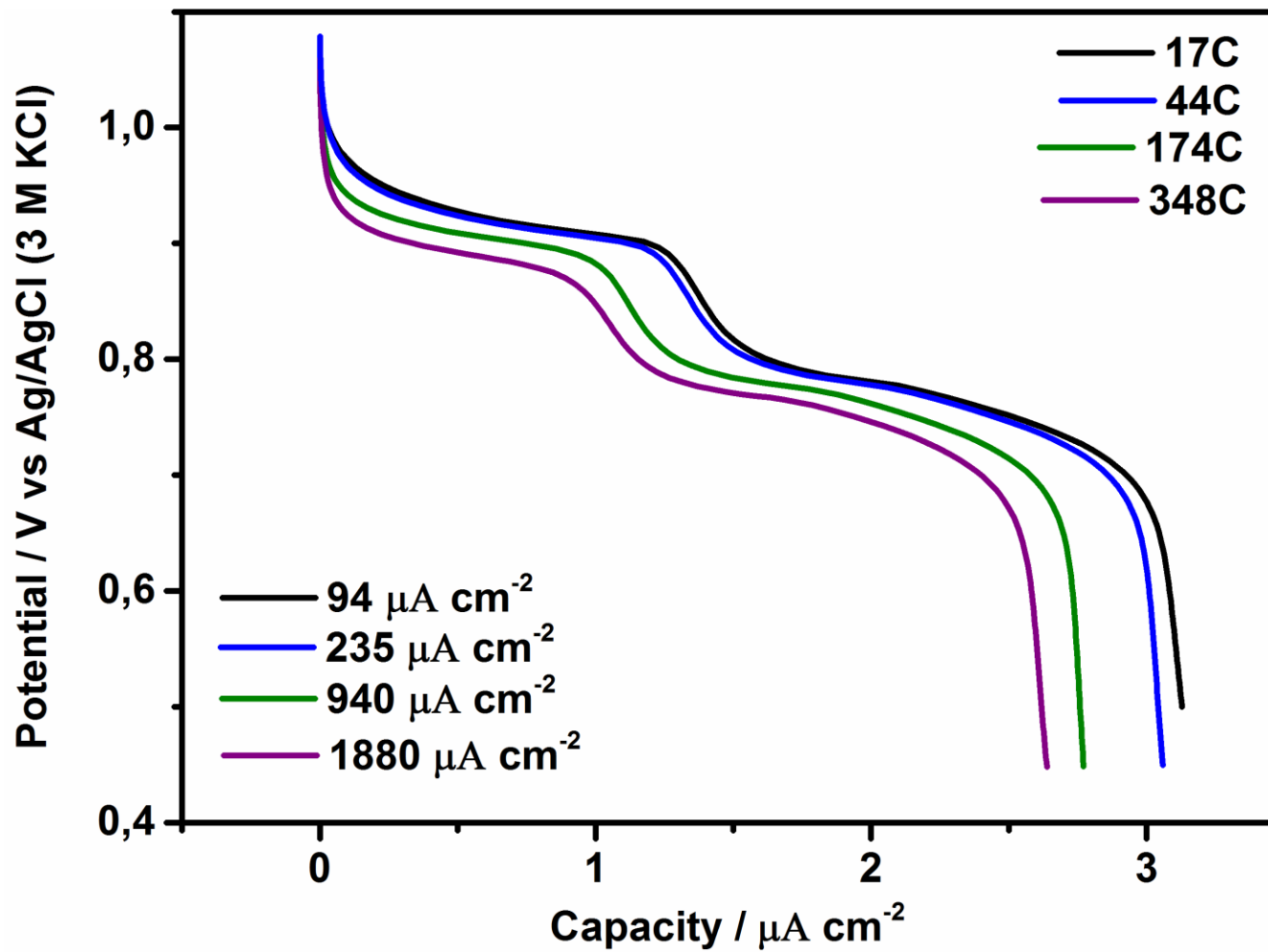
Slope = 0.85

Strong contribution from fast **non-difusion** controlled lithium storage



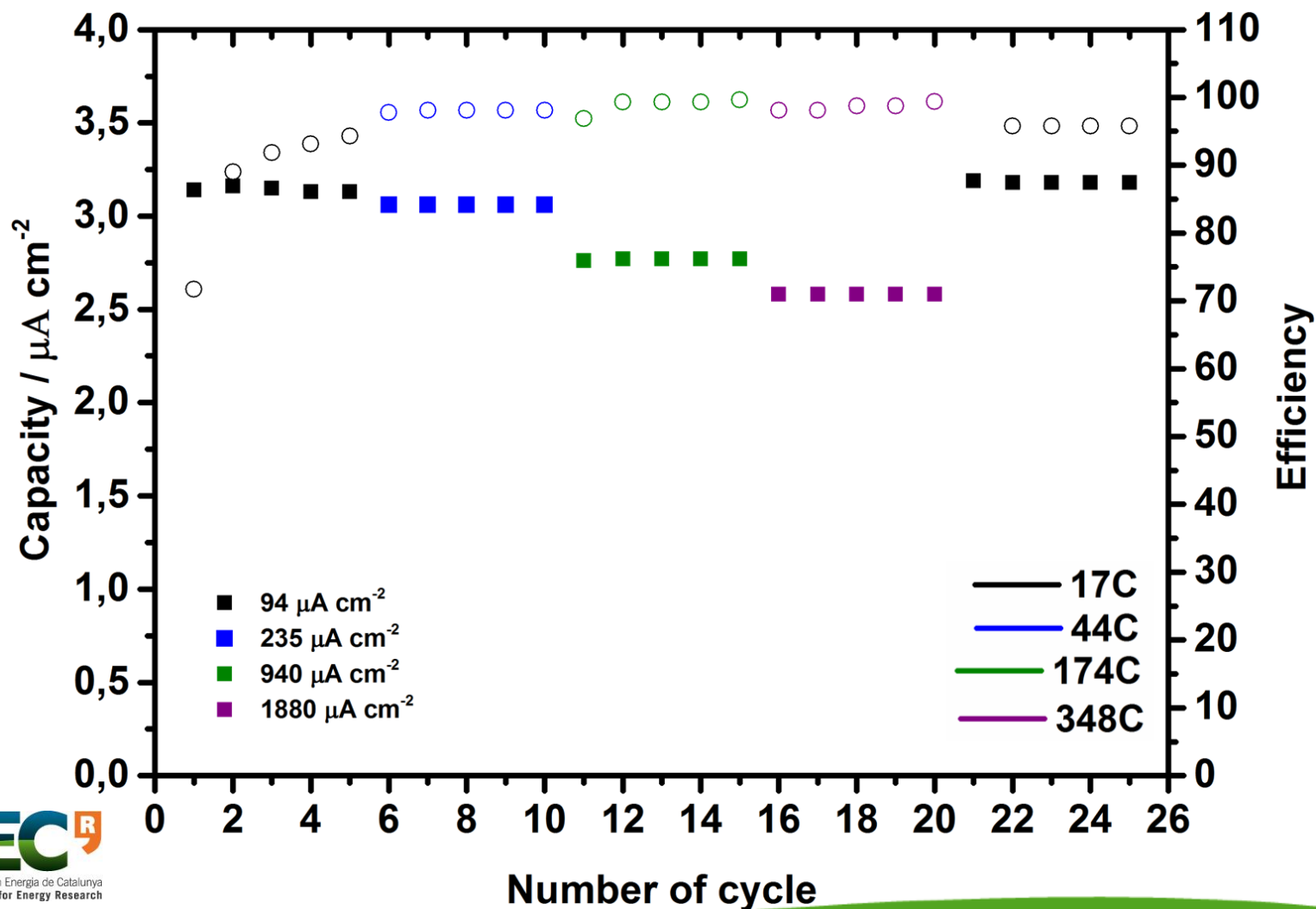
Electrochemical characterization of LiMn_2O_4 thin film

Rate capability

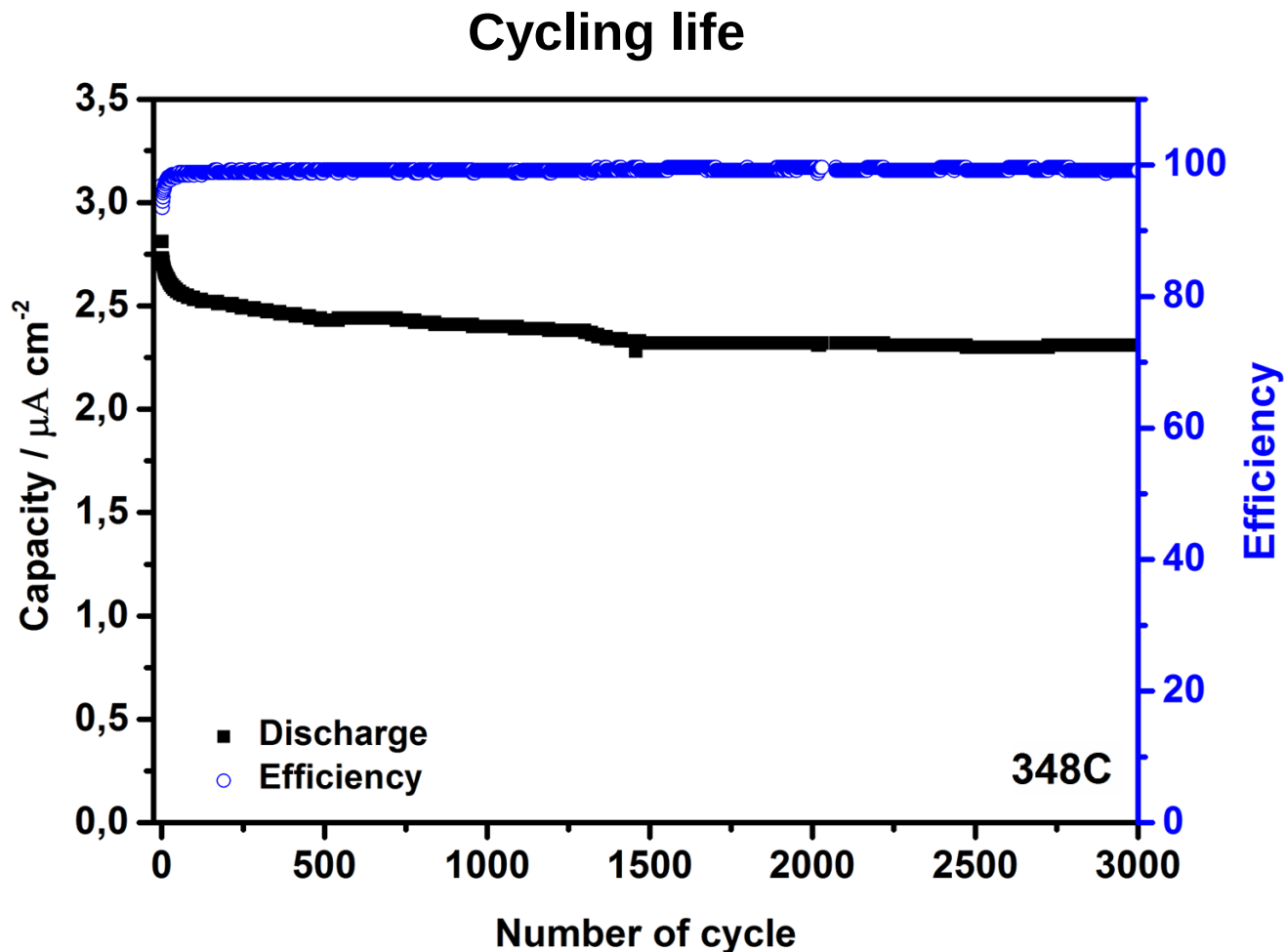


Electrochemical characterization of LiMn_2O_4 thin film

Rate capability



Electrochemical characterization of LiMn_2O_4 thin film



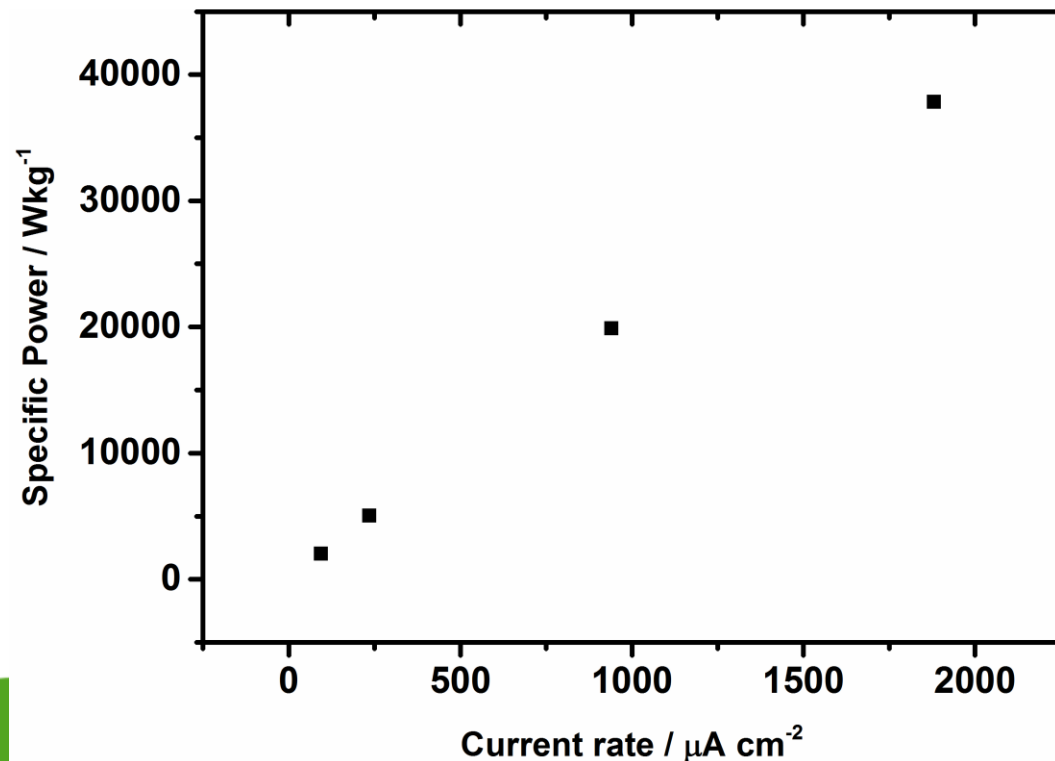
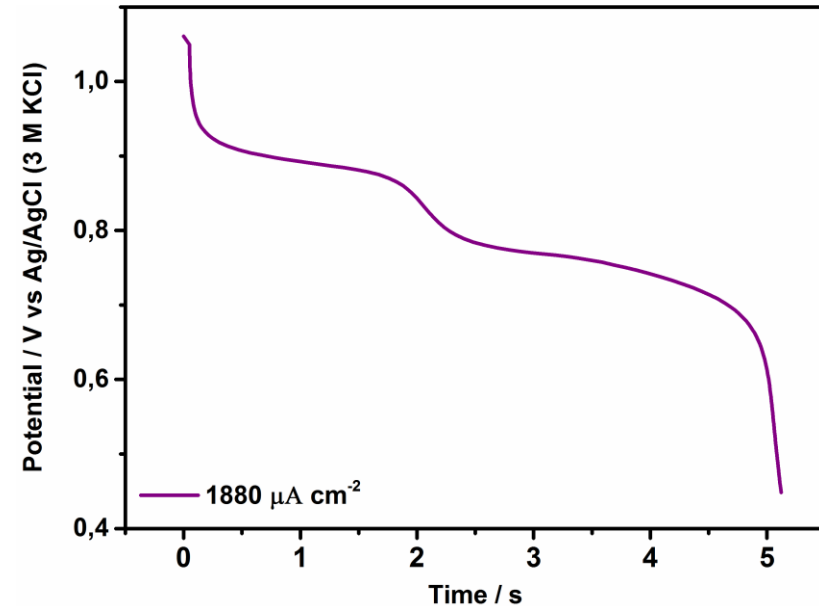
Average capacity retention of **99.996%**

Electrochemical characterization of LiMn_2O_4 thin film

Power supply

The LMO is reduced in ≈ 5 sec

Specific Power close to 38000 Wkg^{-1}





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Amb el finançament de:



THANK YOU FOR YOUR ATTENTION