Low-Cost and High-Performance Fuel Cells Components

E. Peled
School of Chemistry
Tel Aviv University

Starter Fuel Choices Initiative

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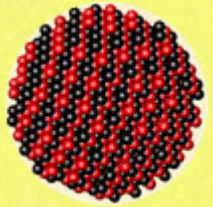
Issues

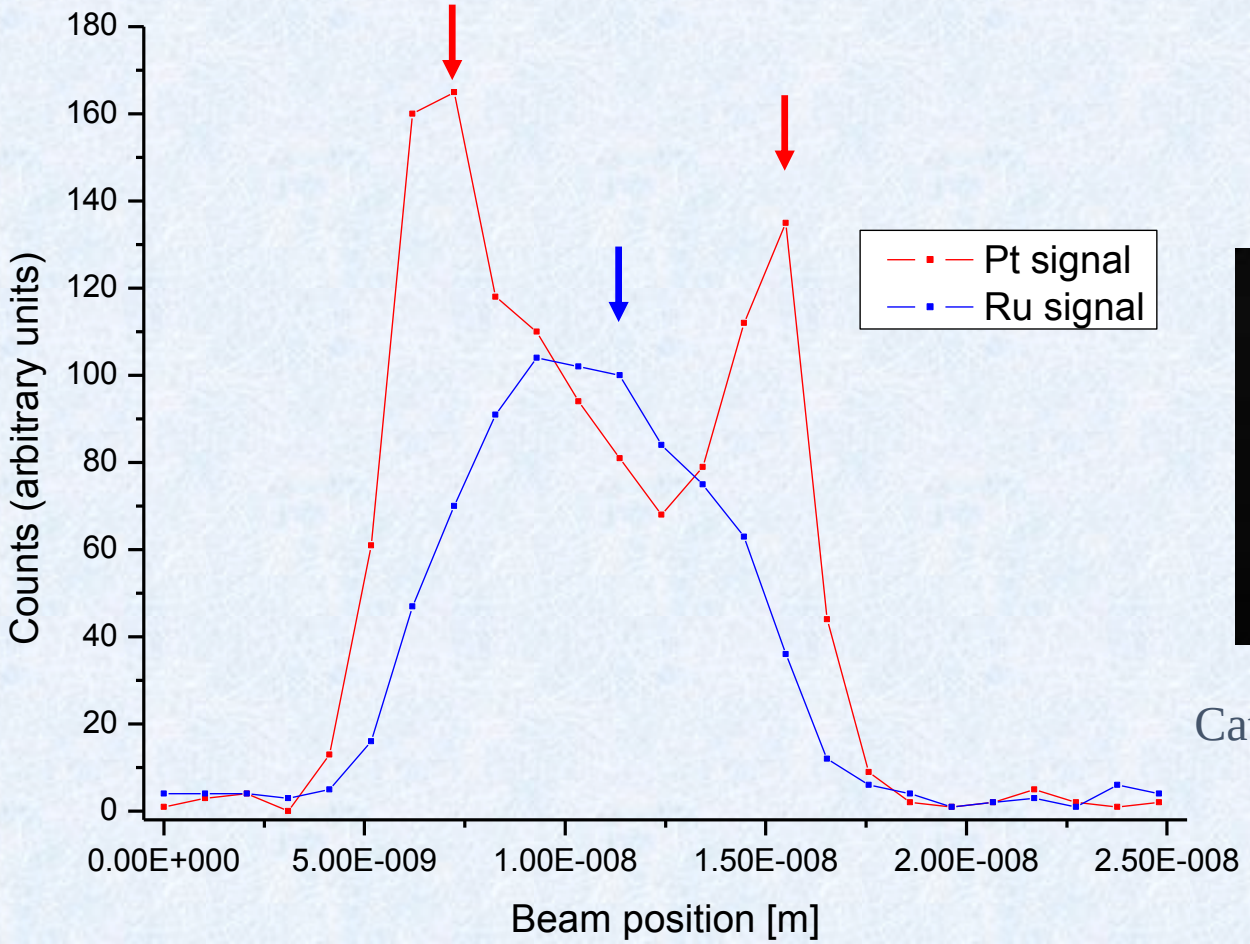
1. Fuel cell core-shell catalysts for: hydrogen oxidation (HOR), oxygen reduction (ORR), methanol and ethylene glycol oxidation
2. Nano porous proton conducting membrane (NP-PCM)
3. A novel proton exchange membrane made of surface-anchored sulfonic acid (SASA)
4. Low cost regenerative fuel cell (RFC) based on HBr solution (TAU-Enstorage)
5. An option for hydrogen production using a low cost and durable HBr electrolyzer

Activity Enhancement of Tel Aviv University (TAU)
Low Platinum, Core-Shell Oxygen Reduction Catalysts

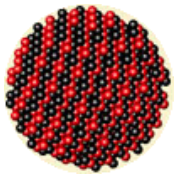
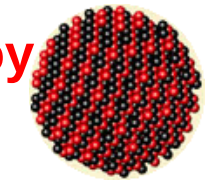
Catalyst	ECSA [m^2/gr TM]	Kinetic mass activity at 0.85V [amp/gr Pt]	**Activity Enhancement per gram of platinum**
Commercial catalyst	48	**115**	
TAU core- shell catalyst (Pt/Ir/XC72) 	35 [m^2/gr PtIr]	**278**	**2.4**

Catalysts for O_2 reduction: Pt/Ru/XC72 – STEM EDS

Ru_{core} – Pt_{shell} structure confirmation



Activity Enhancement of TAU
Low Platinum, Core – Shell Hydrogen Oxidation Catalysts

Experimental results at 0.5M H_2SO_4	ECSA $[m^2/g_{TM}]$	i_0 $[A/cm^2_{ECSA}]$	i_0 /g(Pt) [A/gPt]	Activity enhancement per gram of platinum
50%wt.Pt carbon supported (commercial catalyst)	48	4.9E-4	234	1
TAU catalyst, 15%wt. Pt core-shell 	28	1.5E-3	1428	X 6
TAU catalyst, 10%wt. Pt alloy core-shell 	32	1.3E-3	2142	X 9

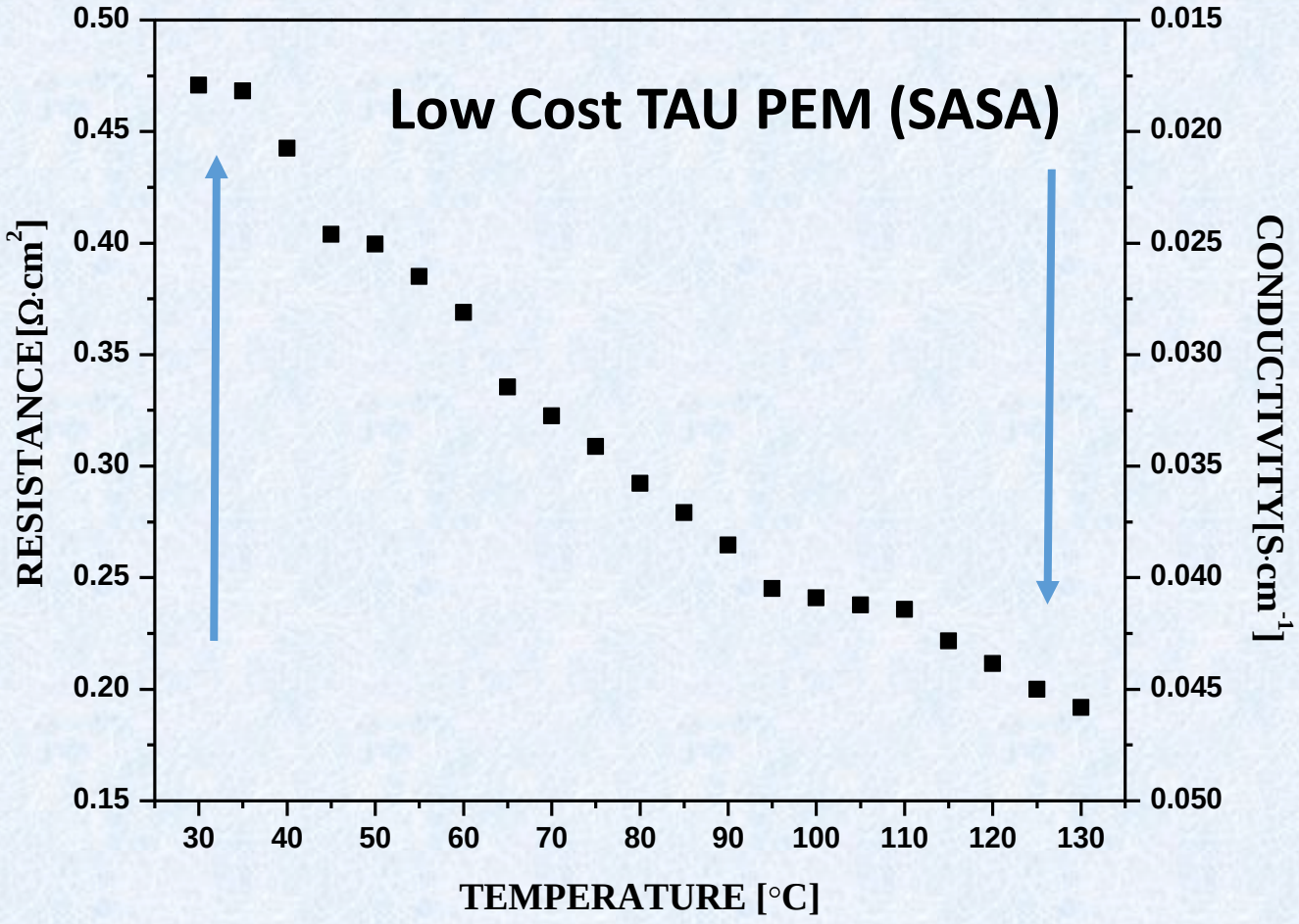
MeOH Oxidation Activity Summary

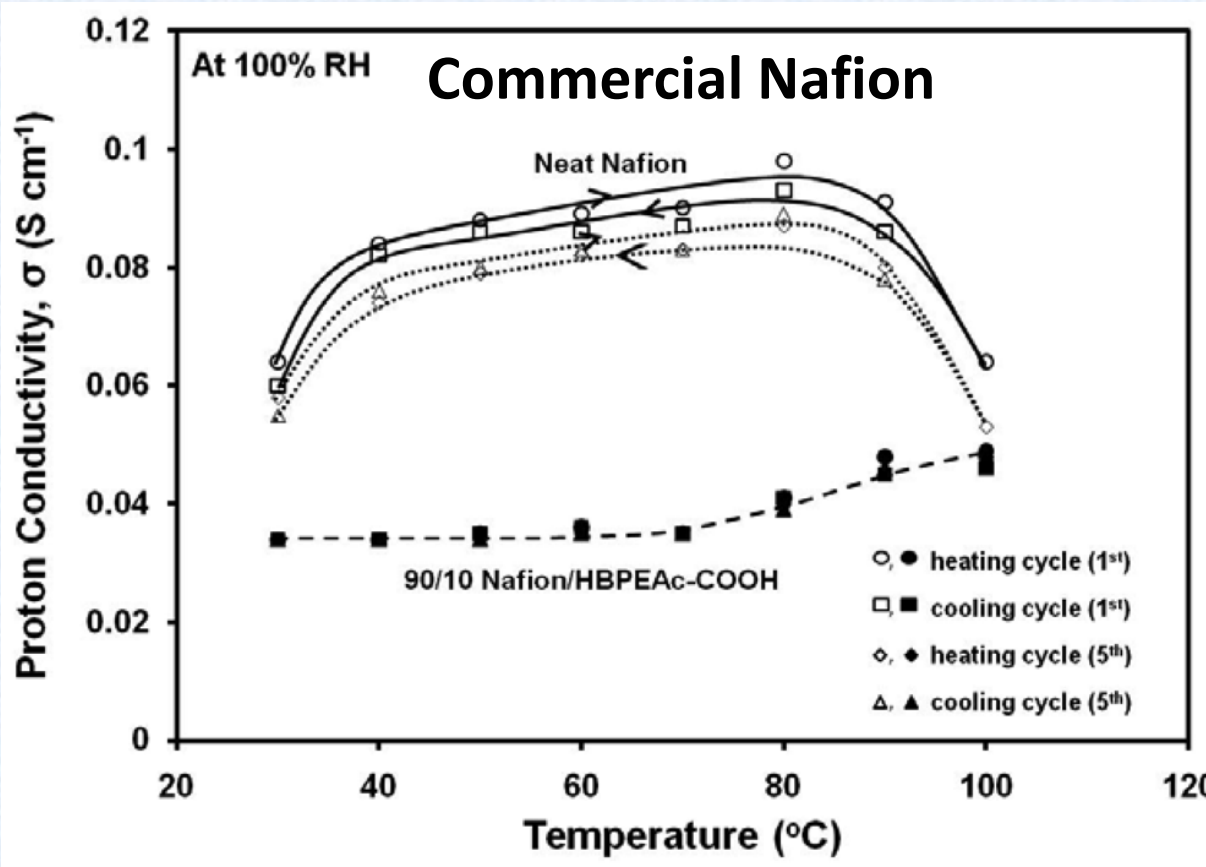
(the arrows indicate the effect of voltage cycling - aging)

Catalyst	Surface atomic composition (XPS)	Mass Activity [amp/gr Pt]
TAU - MA1	Ru:Pt 1:4.28 (↓)	471
TAU - DK4a	Ru:Pt:Ir (↓)1:0.33:028	920
Commercial catalysts	Ru:Pt (↓)1:1.67	346
Commercial catalysts	Ru:Pt (↓)1:1.9	620

Effect of Temperature on the Conductivity of Proton Exchange Membranes (PEMs) – Advantage of the TAU SASA* over 90°C

* Functionalized ceramic powder containing surface-anchored sulfonic acid (SASA)) and PVDF binder. Journal of Power Sources (2008)

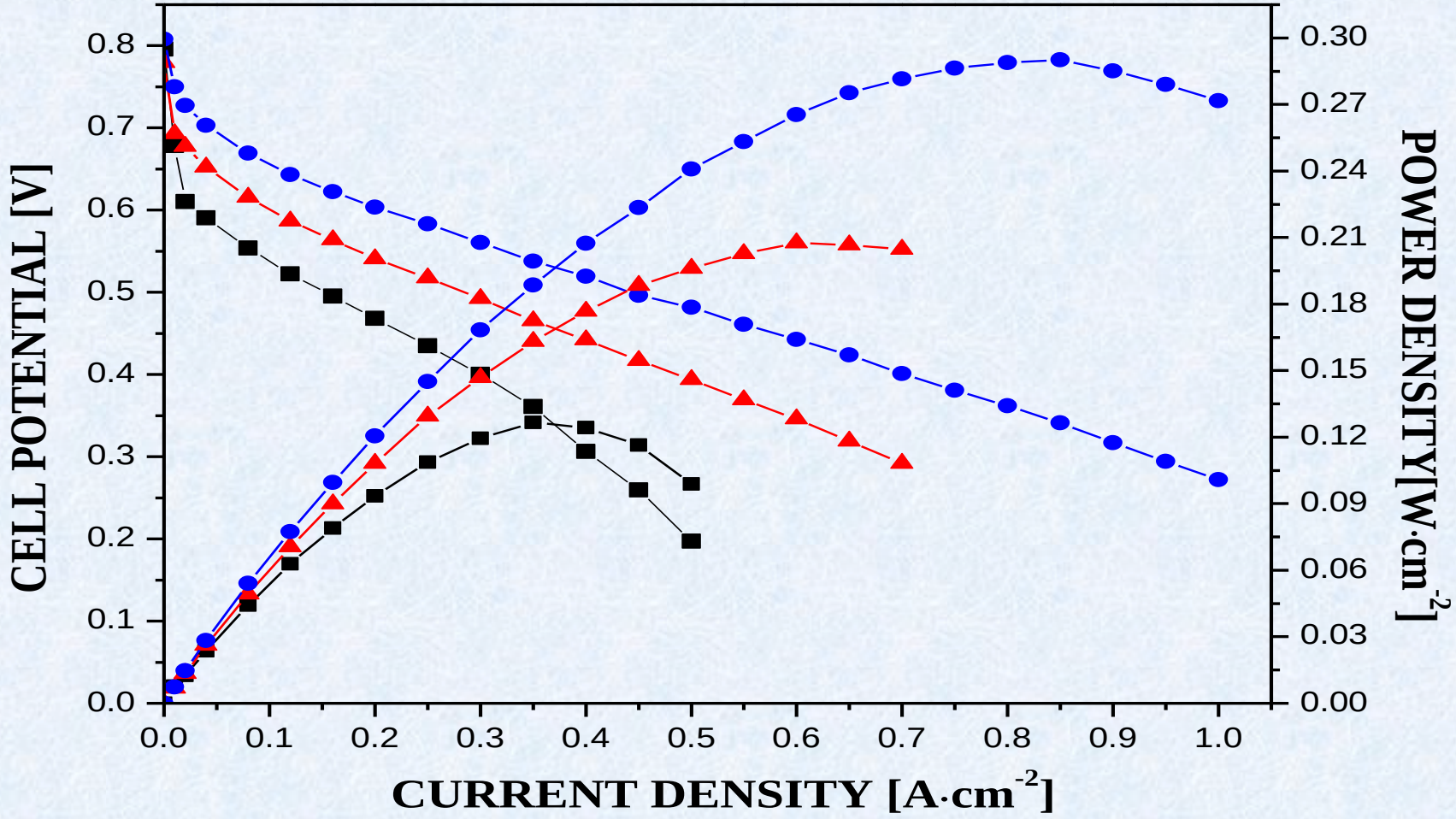




Direct Methanol Fuel Cell Based on ~100 µm SASA membrane

-■- 80°C -▲- 110°C -●- 130°C:

(functionalized ceramic powder containing surface-anchored sulfonic acid (SASA)) and PVDF binder. Journal of Power Sources (2008)



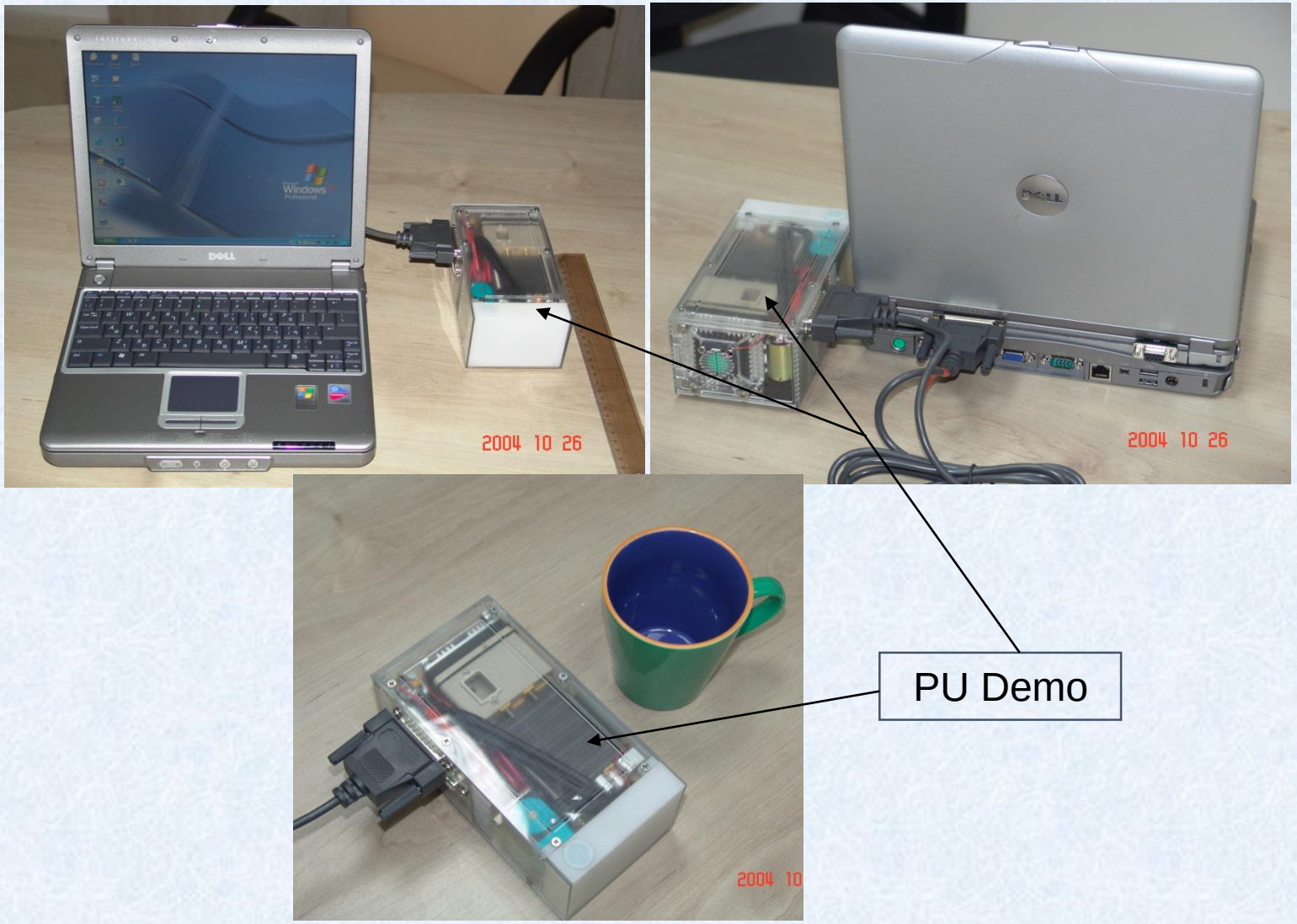
Ethylene Glycol Oxidation Activity - Summary

(the arrows indicate the effect of voltage cycling - aging)

Catalyst	Surface atomic composition (XPS)	Mass Activity [amp/gr Pt]
TAU - MA1 (Pt + Ru)	Ru:Pt (↑) 1:4.28	241
TAU - DK6a (Ru + Alloy)	Ru:Pt (↓)1:0.47	526
TAU - DK4a (alloy)	Ru:Pt:Ir (↓)1:0.33:028	341
Commercial catalysts	Ru:Pt (↓)1:1.67	263
Commercial catalysts	Ru:Pt (↓)1:1.9	316

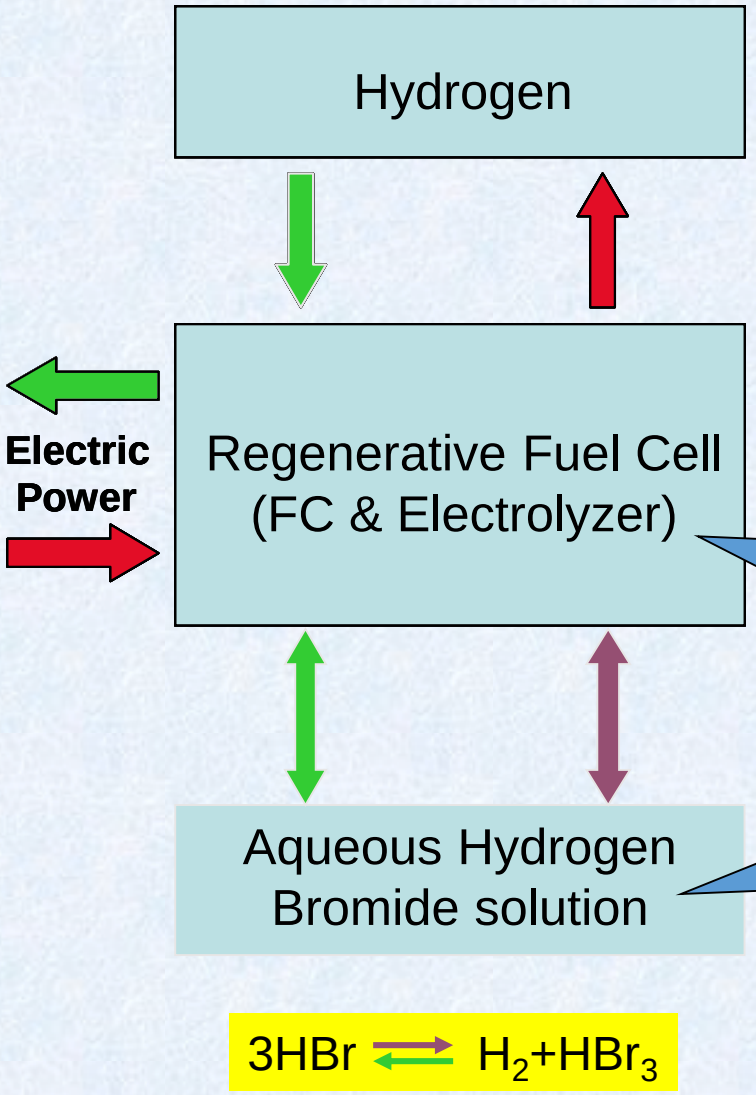
Tel Aviv University – Direct Methanol Fuel Cell (system integration)

Power Unit Demo



EnStorage Energy Storage System

(based on TAU NP-PCM membrane and catalysts)



- Totally sealed system
- No emissions or solid waste
- Infinite electrolyte life
- >75% total efficiency

Power Generation
250kW to 1GW

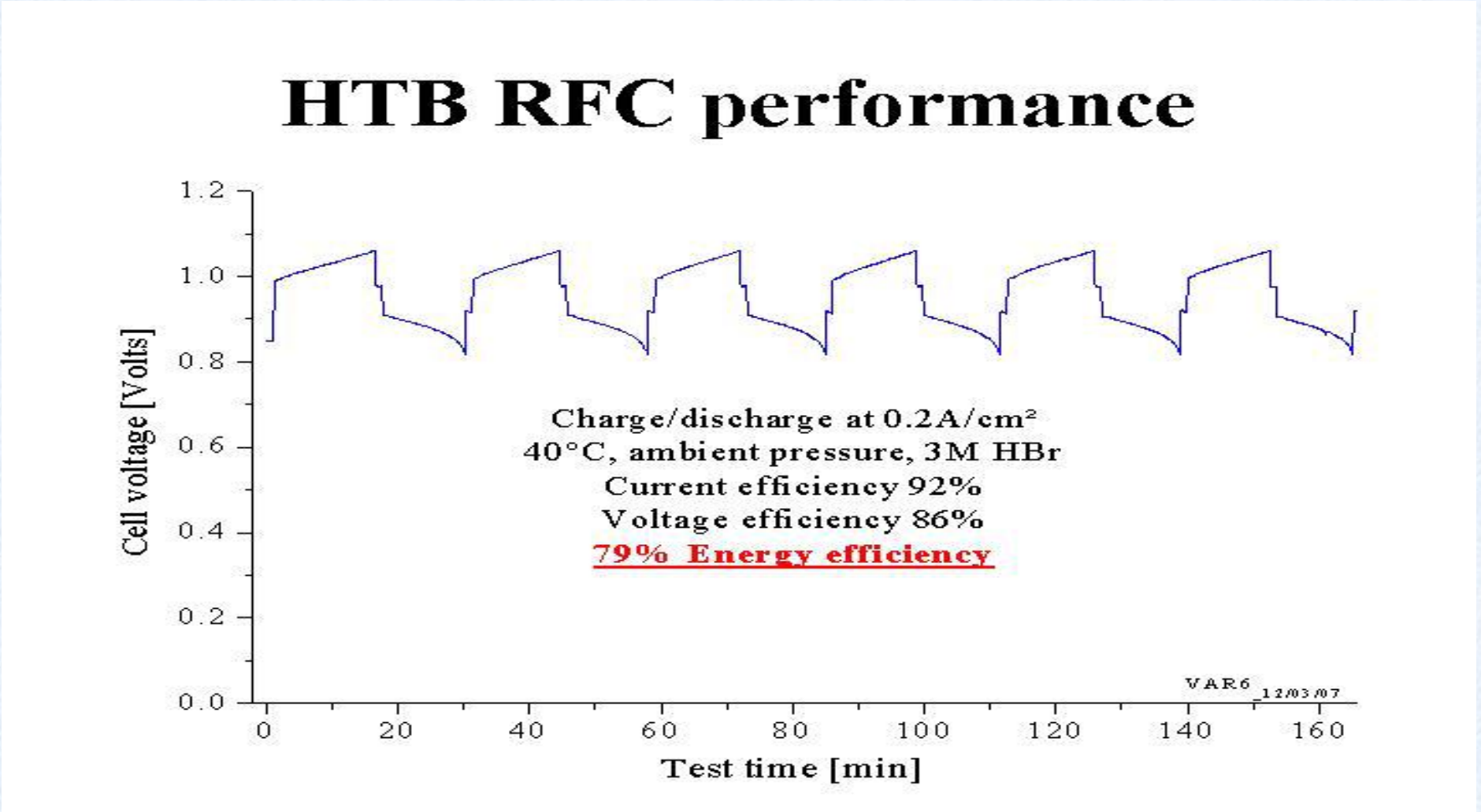
Proprietary Membrane:
3x higher power density
➔ 3x lower cost/kW

Energy Storage
1MWh to 10GWh

lower cost chemicals
➔ 4x lower cost/kWh

Cycling of a Single Hydrogen Three Bromide RFC

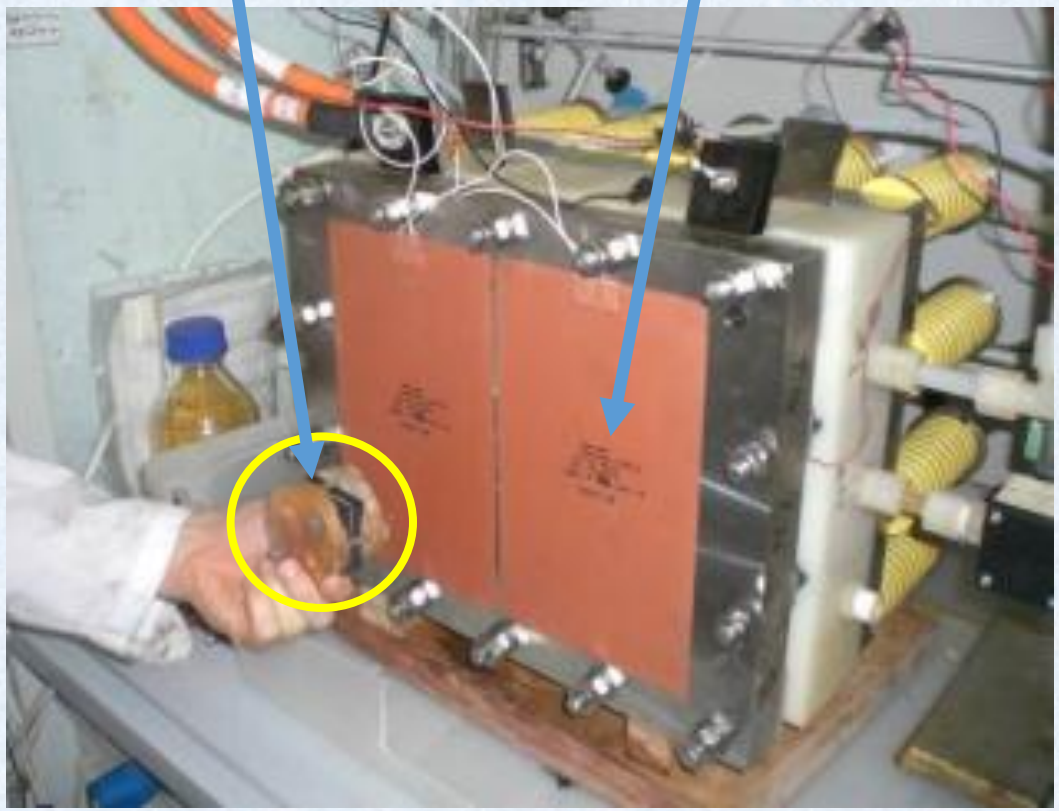
$3HBr \rightleftharpoons H_2 + HBr_3$



From 1W (TAU) to 150kW Grid Connected RFC Systems (in construction)

EnStorage is developing and deploying its system with **AREVA** and **Schneider Electric** – The FlowBox Project

1W → 1kW



150 kW, 6 hours storage
for solar and wind farms

Thank you for your attention

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