REPORT ON ELECTROLYSIS EXPERIMENTS AT ENERGETICS TECHNOLOGIES

I. Dardik, T. Zilov, H. Branover, A. El-Boher, E. Greenspan, B. Khachaturov, V. Krakov, S. Lesin, A. Shapiro and M. Tsirlin

Energetics Technologies
P.O.Box 3026
Omer Industrial Park
Omer, Israel
lesin@energetics.il.co

Presented at the 8th International Workshop
on Anomalies in Hydrogen / Deuterium loaded Metals
13-18 October 2007
Catania, Sicily

Introduction

The primary objectives of the Energetics Technologies experimental program are:

(1) Improvement of reproducibility of excess heat generation
(2) Amplification of power and energy gain

The program focuses on electrolytic cells driven by I. Dardik's SuperWaves

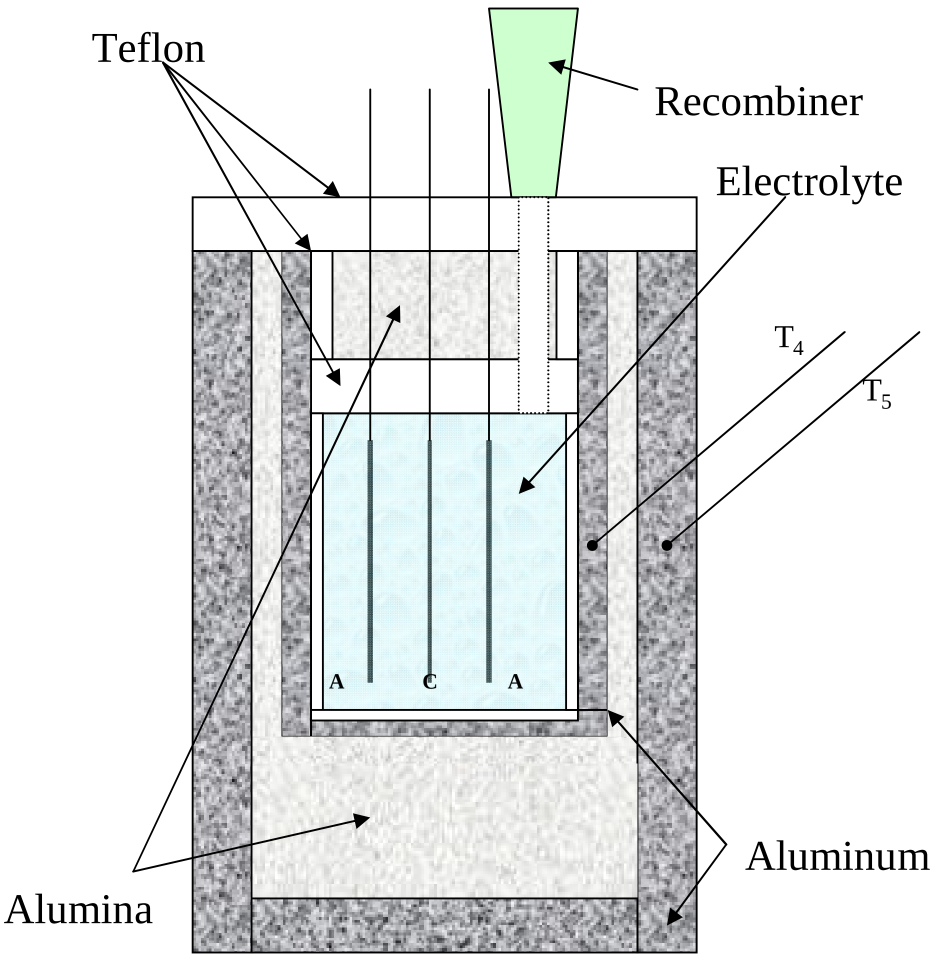
Several experimental approaches are being pursued:

- Optimization of Super Wave
- Modify cathode surfaces by special annealing-etching procedures jointly developed with ENEA (Frascati) and the University of Rome
- Modify cathode surfaces by SuperWaves glow discharge etching
- Develop new cathodes
- Electrolysis with ultrasonic wave excitation

Experimental results in each of these research areas are reported along with results from metallurgical and the X-ray analysis of the cathodes.

Successful replications of Energetics heat production was accomplished at SRI and at ENEA (Frascati); results will be presented separately.

ET ELECTROLYTIC CELL

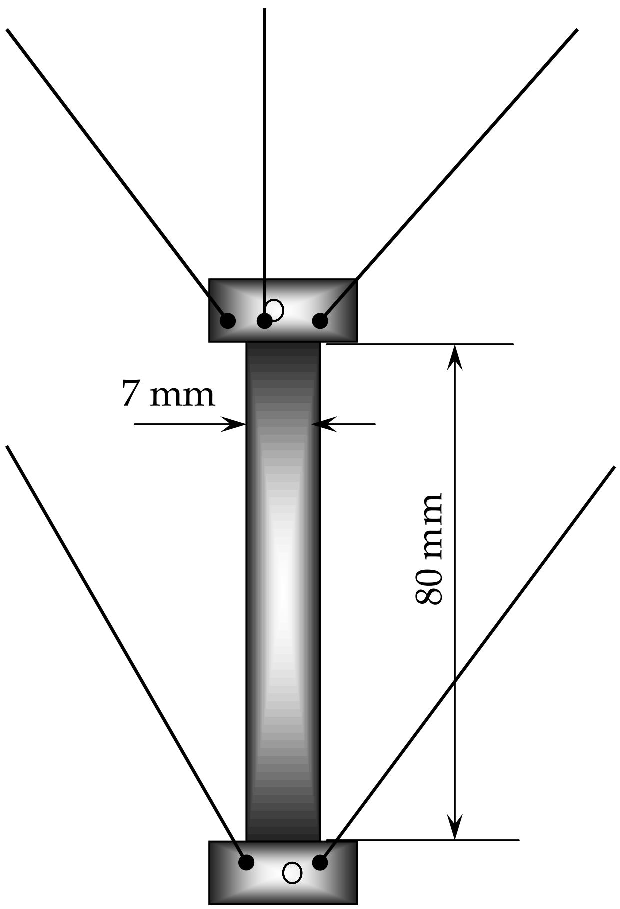


0.1M LiOD in low tritium content D_2O (230 ml)

System assembly

EC is inside a Teflon beaker that is placed inside an isoperibolic calorimeter that is placed inside a thermo-stated water bath (3 cells per bath)

Typical EC cathode



Pd foil -- 50 μm

Annealed at 870^0C in vacuum for 1h

Etched:

1) in Nitric Acid 65-67% 1 min
2) in Aqua Regia 1:1 water solution 1 min

Rinsed:

1) D_2O four times
2) Ethanol 95% twice
3) Ethanol Absolute once

Dried:

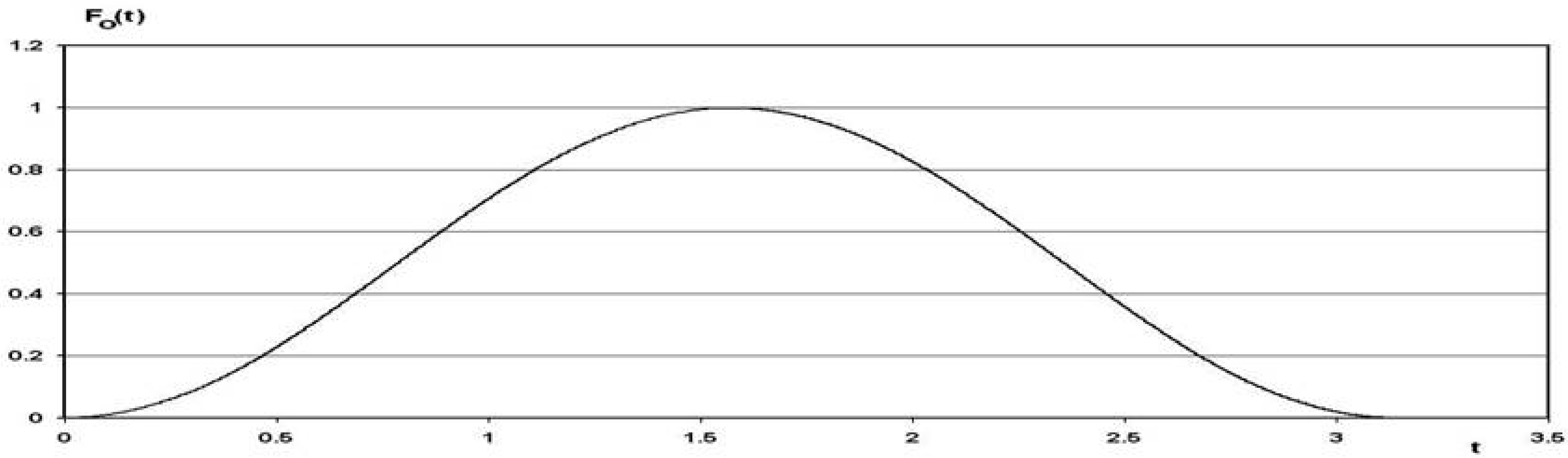
in vacuum at ambient temperature for 24 h

Electrolyte:

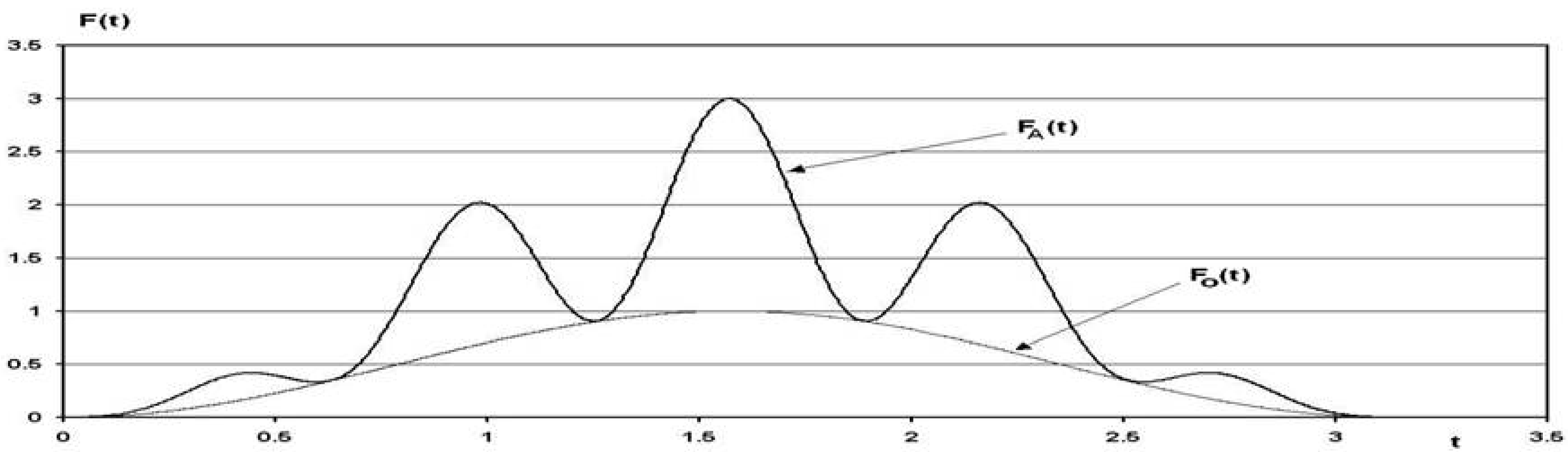
0.1M LiOD in D_2O of low tritium content; 230 ml

SuperWaves formation principles

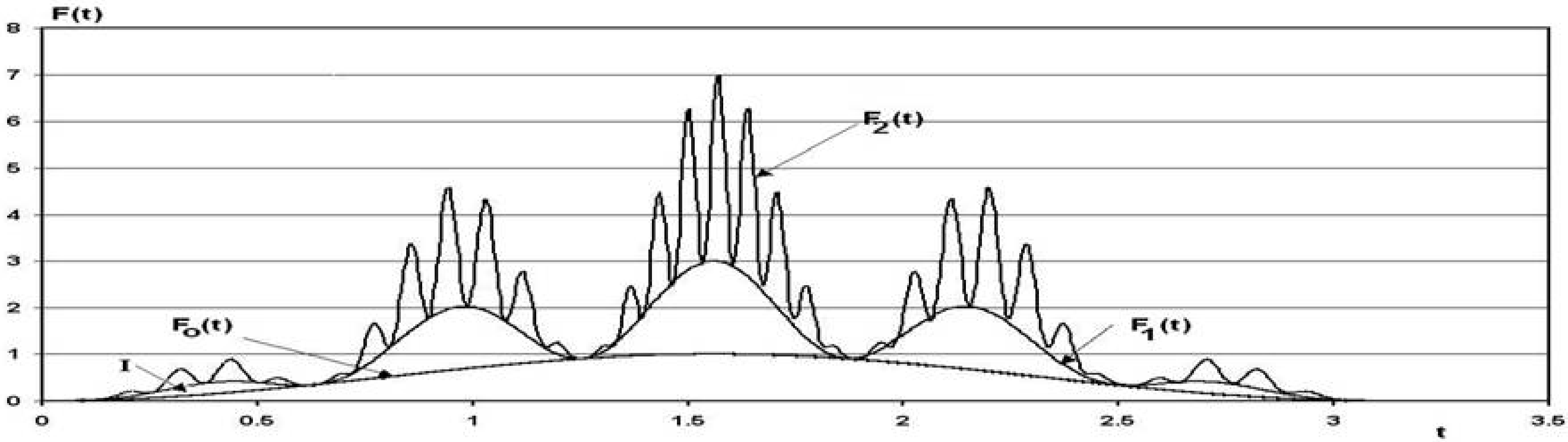
$$F_0(t) = A_0 \sin^2(\omega_0 t)$$



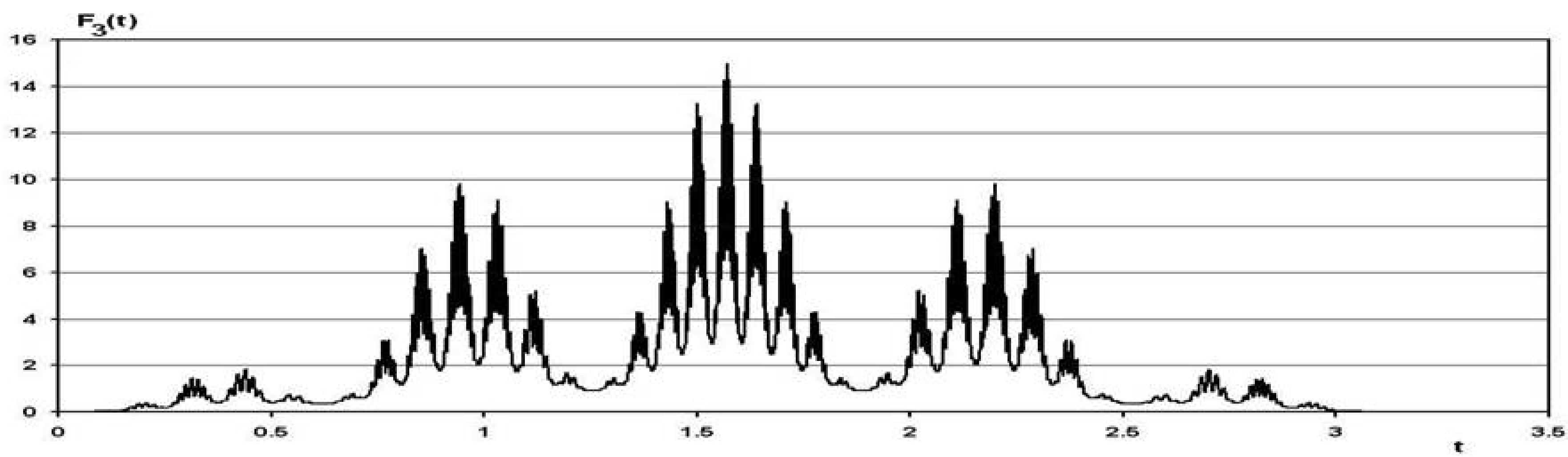
$$F_1(t) = A_0 \sin^2(\omega_0 t)(1 + A_1 \sin^2(\omega_1 t))$$



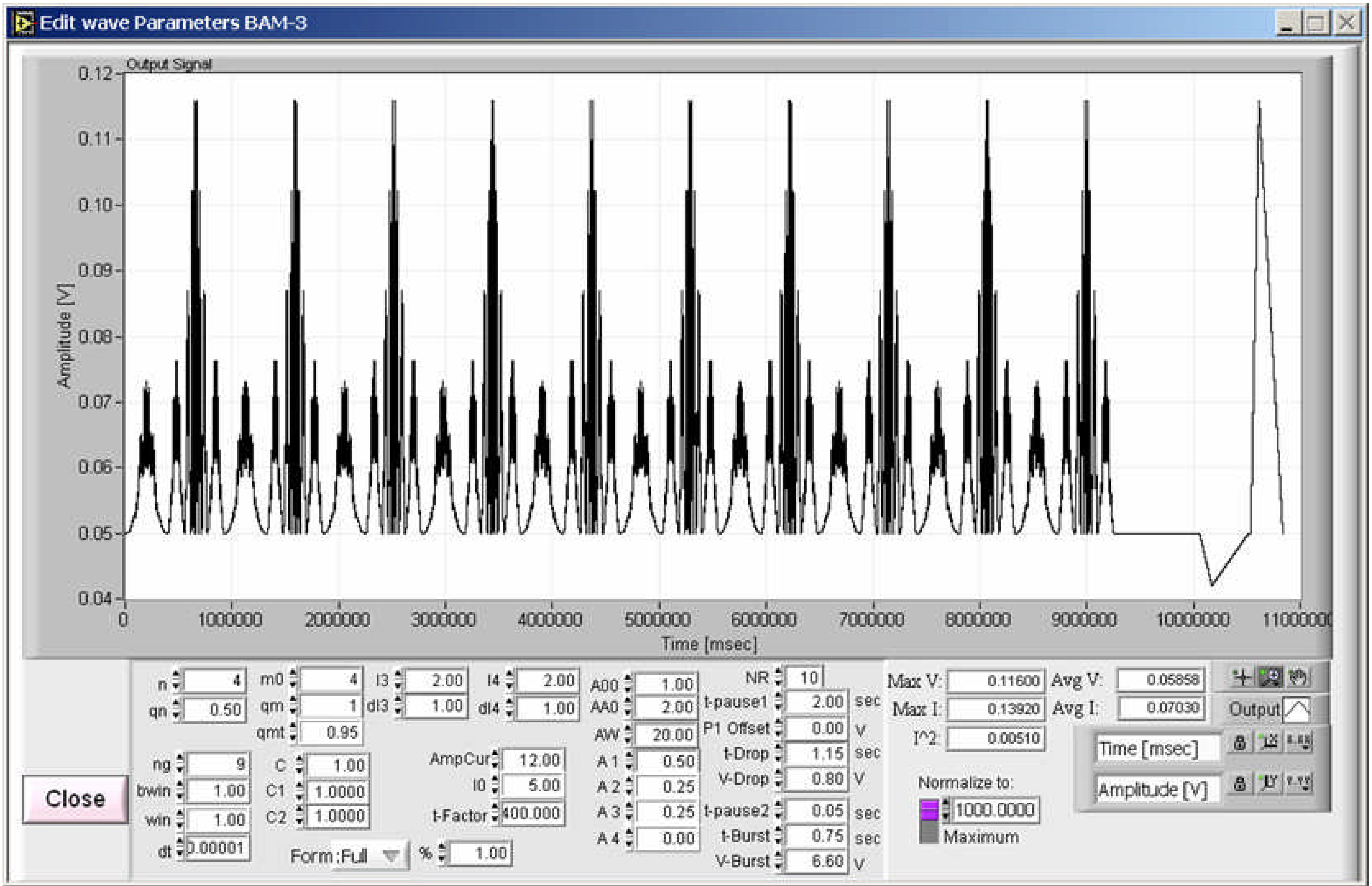
$$F_2(t) = A_0 \sin^2(\omega_0 t)[1 + A_1 \sin^2(\omega_1 t)(1 + A_2 \sin^2(\omega_2 t))]$$



$$F_3(t) = A_0 \sin^2(\omega_0 t)[1 + A_1 \sin^2(\omega_1 t)(1 + A_2 \sin^2(\omega_2 t)(1 + A_3 \sin^2(\omega_3 t)))]$$



Typical SuperWave



Reproducibility

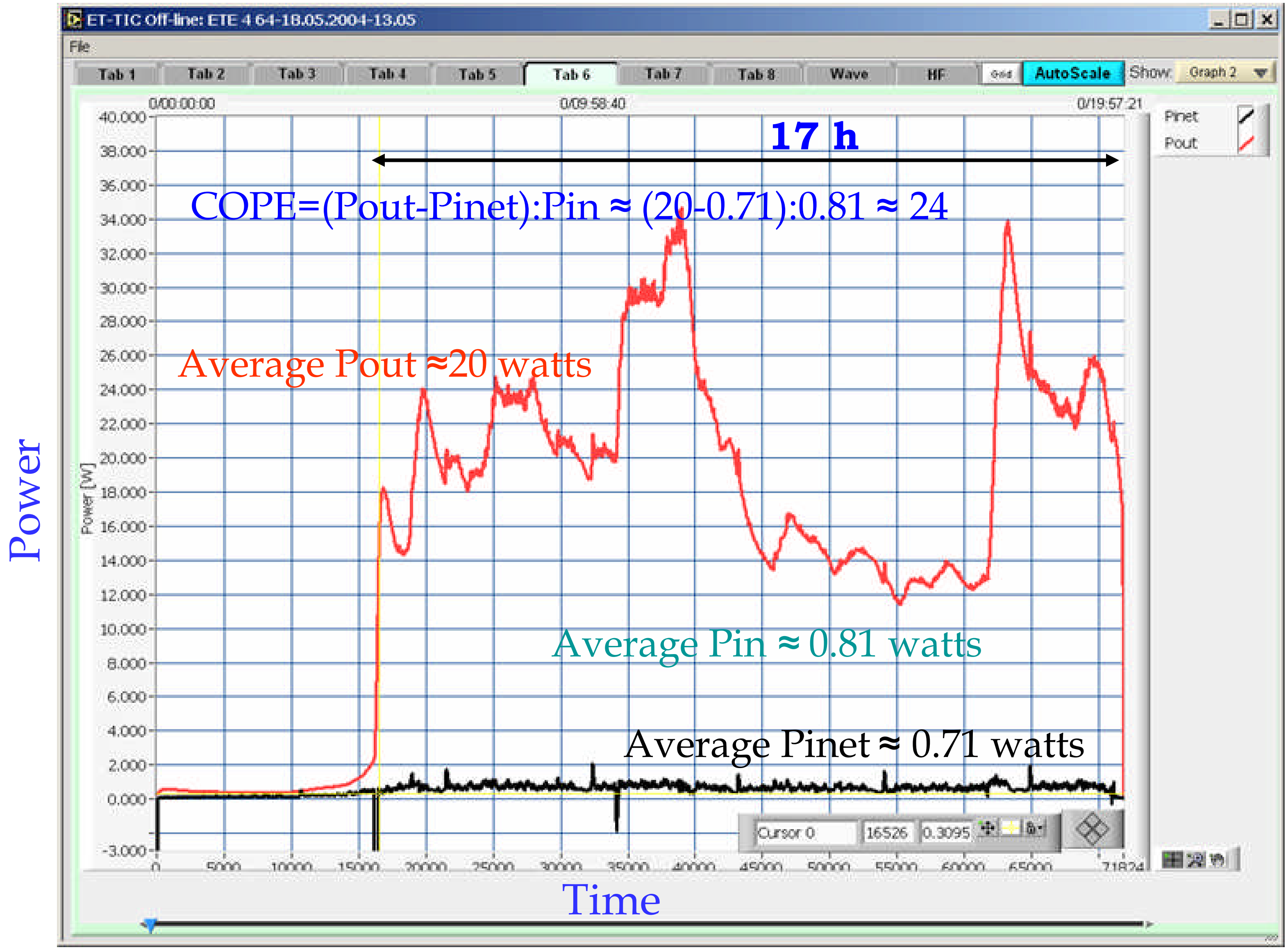
Number of experiments by category	№ of exp.	Excess Heat	
		№ of exp.	% of giving EH
50 microns Pd foil - regular*	98	16	**16**
50 microns Pd foil* - optically tested**	20	3	**15**
Glow discharge etching	21	10	**50**
PdNi alloy	16	3	**19**
Multilayer*** Pd/Me(MeO)/Pd [Me ≡ Metal]	25	6	**24**
Single Wall Carbon Nano Tubes Pd composite***	59	11	**19**
Total	253	49	**19**
US excited electrolysis	29	17	**59**

*samples prepared by Dr. V.Violante et al

**samples tested by Prof. C.Cibilia et al

***samples prepared by Dr. A.Lipson et al.

Target - Excess power like in Exp. # 64a

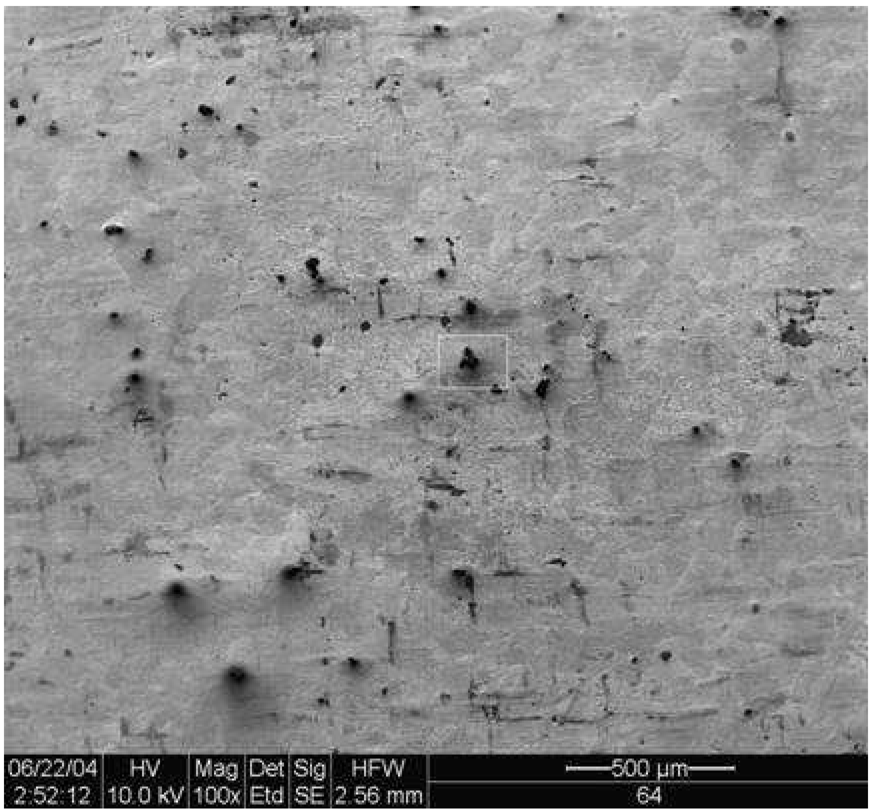


Excess Power of up to 34 watts; Average ~20 watts for 17 h

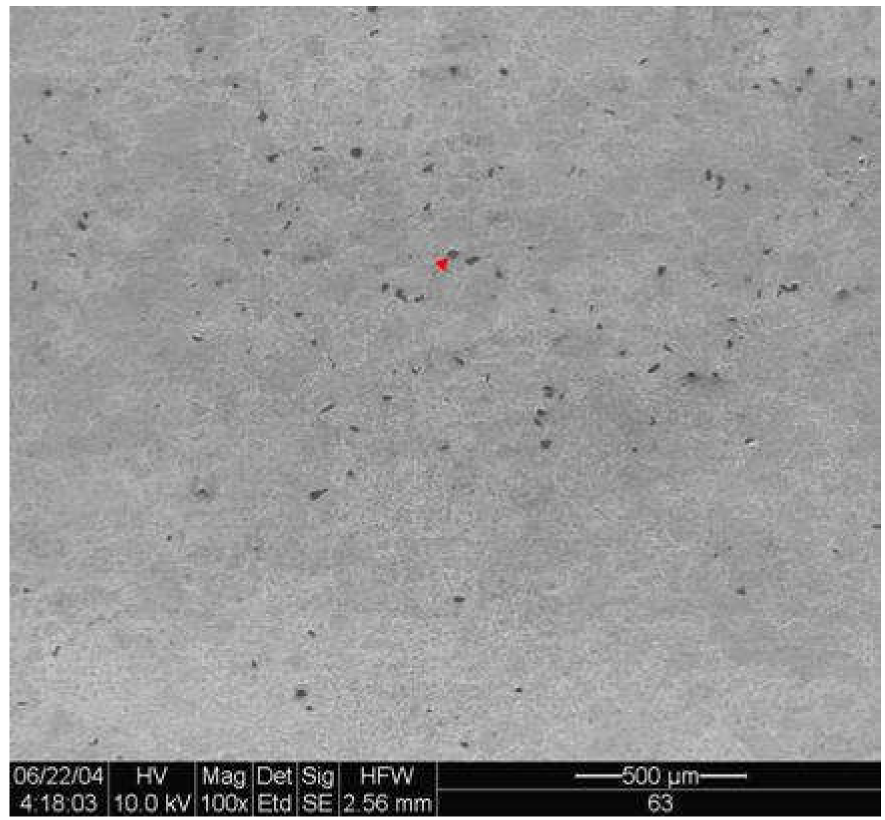
SEM-EDS analysis of foil # 64 vs. 63

Surface of Pd foil after rolling and annealing at 870^0C

foil #64 (EH)
many "black spots"

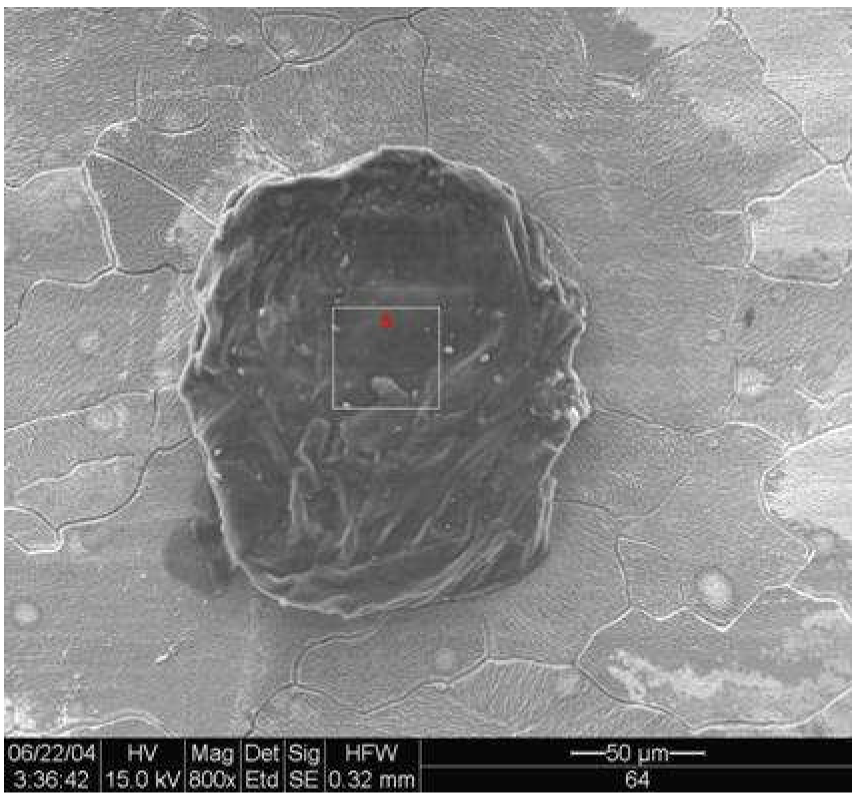


foil #63 (no EH)

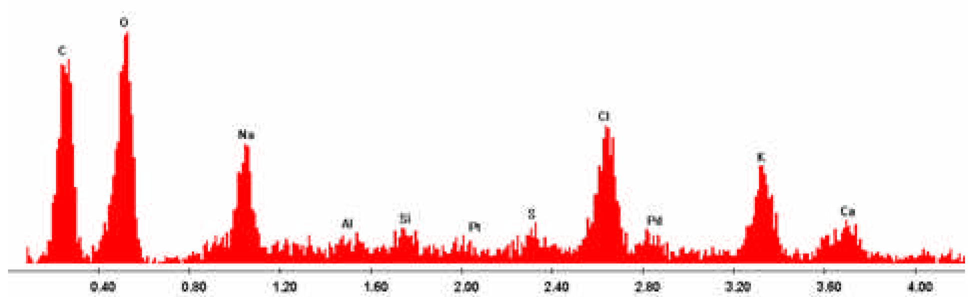


View of typical black spot on # 64 and its composition

SEM-EDS



Element	Wt %	At %
C	35.77	52.48
O	26.19	28.84
Na	4.92	3.77
Al	0.43	0.28
Si	1.05	0.66
Pt	0.39	0.04
S	1.44	0.79
Cl	10.68	5.31
Pd	2.55	0.42
K	11.07	4.99
Ca	5.52	2.43
Total	100.00	100.00



Cathode surface modification

An attempt was made to create cathode surface similar to that of foil #64:

- embed "black spots" on the surface using special rolling procedure
- anneal under similar condition
- find the right etching procedure
- specify the surface properties by an optical method

Foil type	№ of experiments	№ of giving EH	% of giving EH
50 microns Pd foil - regular	98	16	**16**
50 microns Pd foil - optically screened	20	3	**15**

- Unfortunately, no difference has been found!
- Power gain is relatively low (10-15%)

Glow Discharge etching – Statistics

First Series

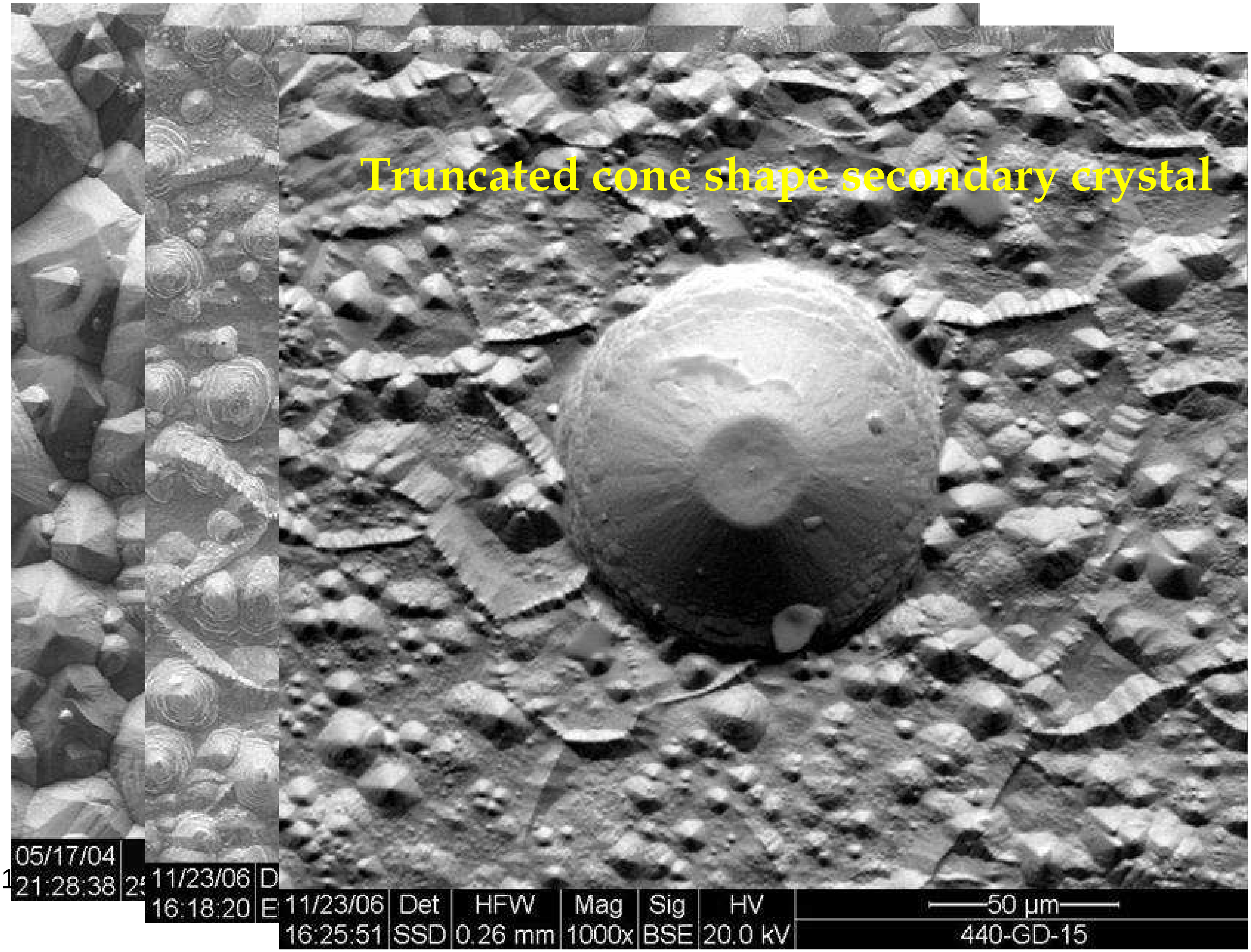
Gas	# of significant* experiments	# giving EH	% of Power gain	R/R_0
Argon	1	1	10-20	peak
Argon-Oxygen	0	0	n/a	n/a
Deuterium- Helium	5	2	17-20	1.93-1.32
Deuterium	5	1	25-75	1.87-1.26
Helium	2	1	8-10	1.88-1.62
Total	**13**	**5**	**38%**	

Recent Series

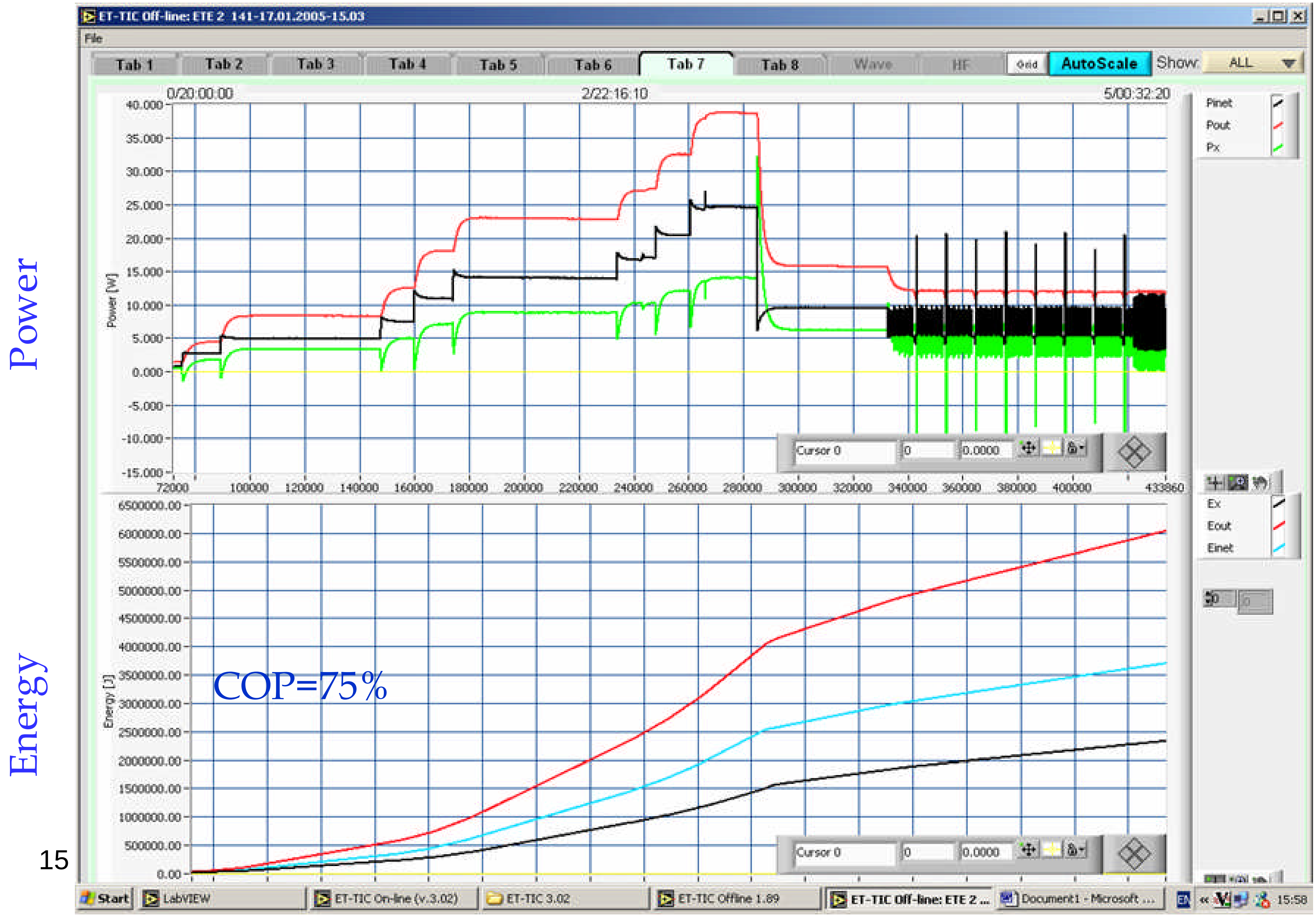
Gas	# of significant* experiments	# giving EH	% of Power gain	R/R_0
Deuterium	8	5	10-25	1.95-1.22
Total	**8**	**5**	**62.5%**	

* Experiments without Glow Discharge induced defects.

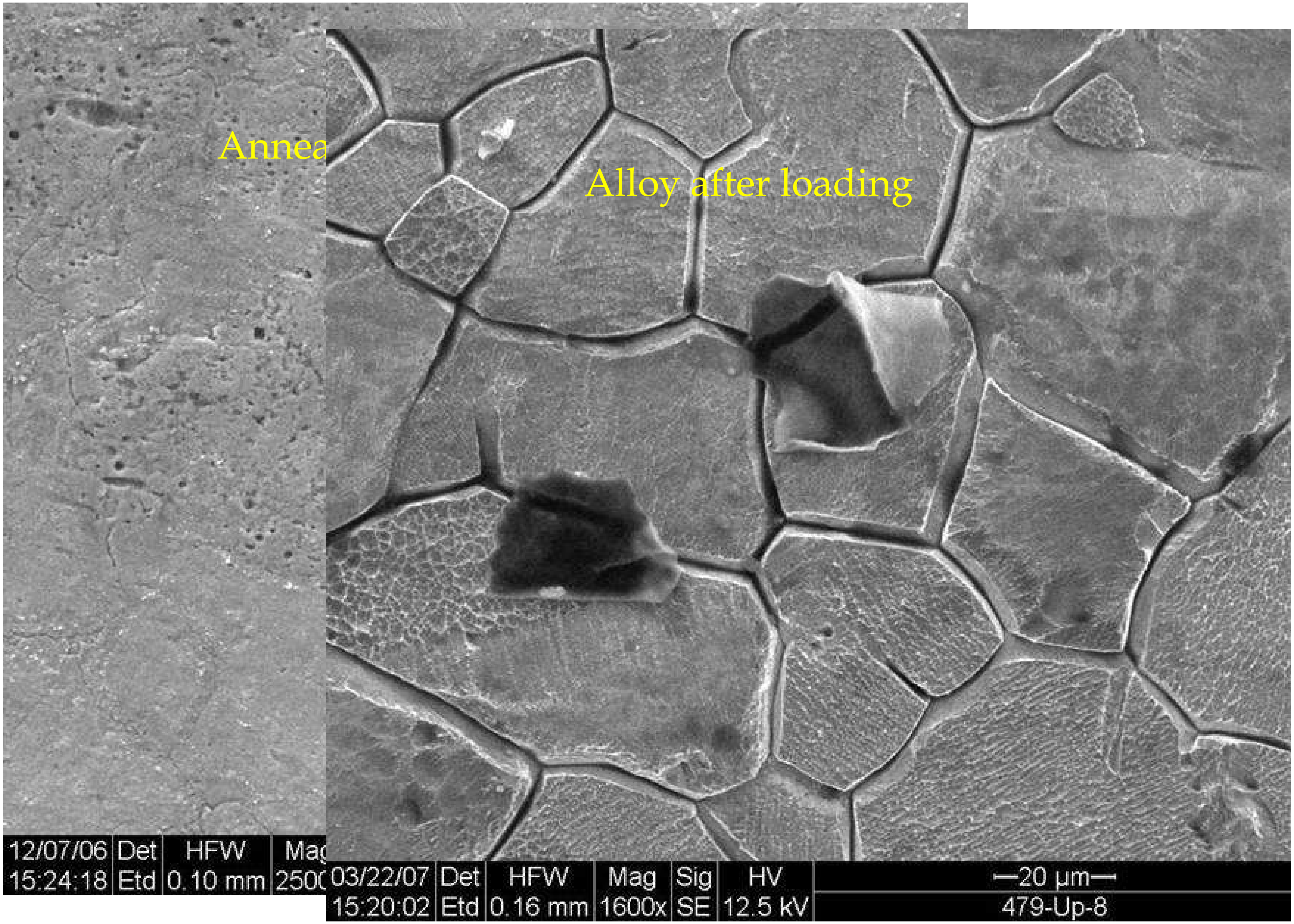
Glow Discharge etching – tremendous surface restructuring



Exp.#141 after deuterium GD etching



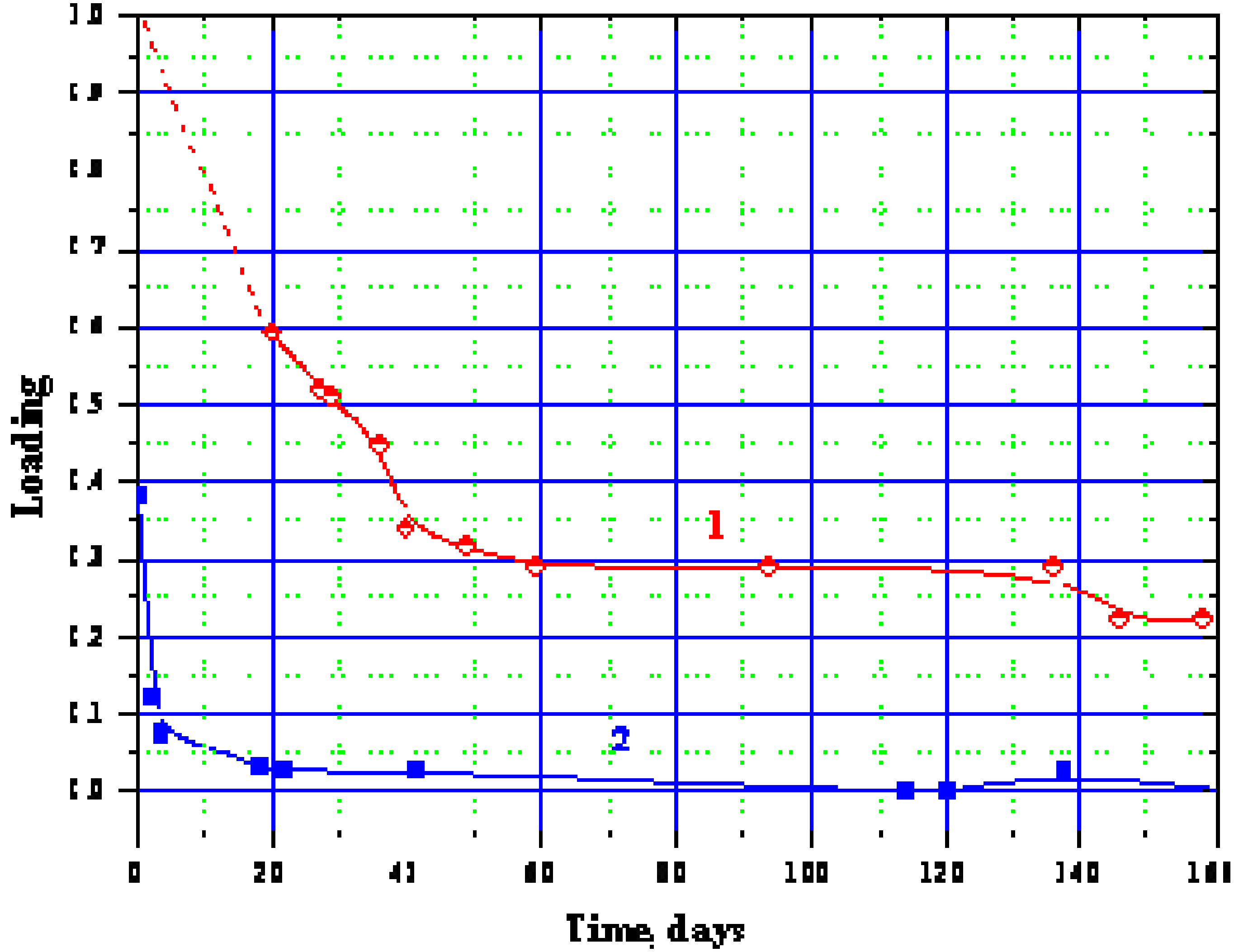
Commercial alloy 5Ni95Pd



High loading for NiPd alloy

*) F.A. Lewis, I.Lewis and S.G.McKee “Correlation of the relationships between hydrogen content, hydrogen chemical potential and electrical resistivity for palladium alloy-hydrogen systems: possible catastrophe theory representation of the relationships”. Journal of the Less-Common Metals, 101(1984) 503-521

Kinetics of deloading outside cell

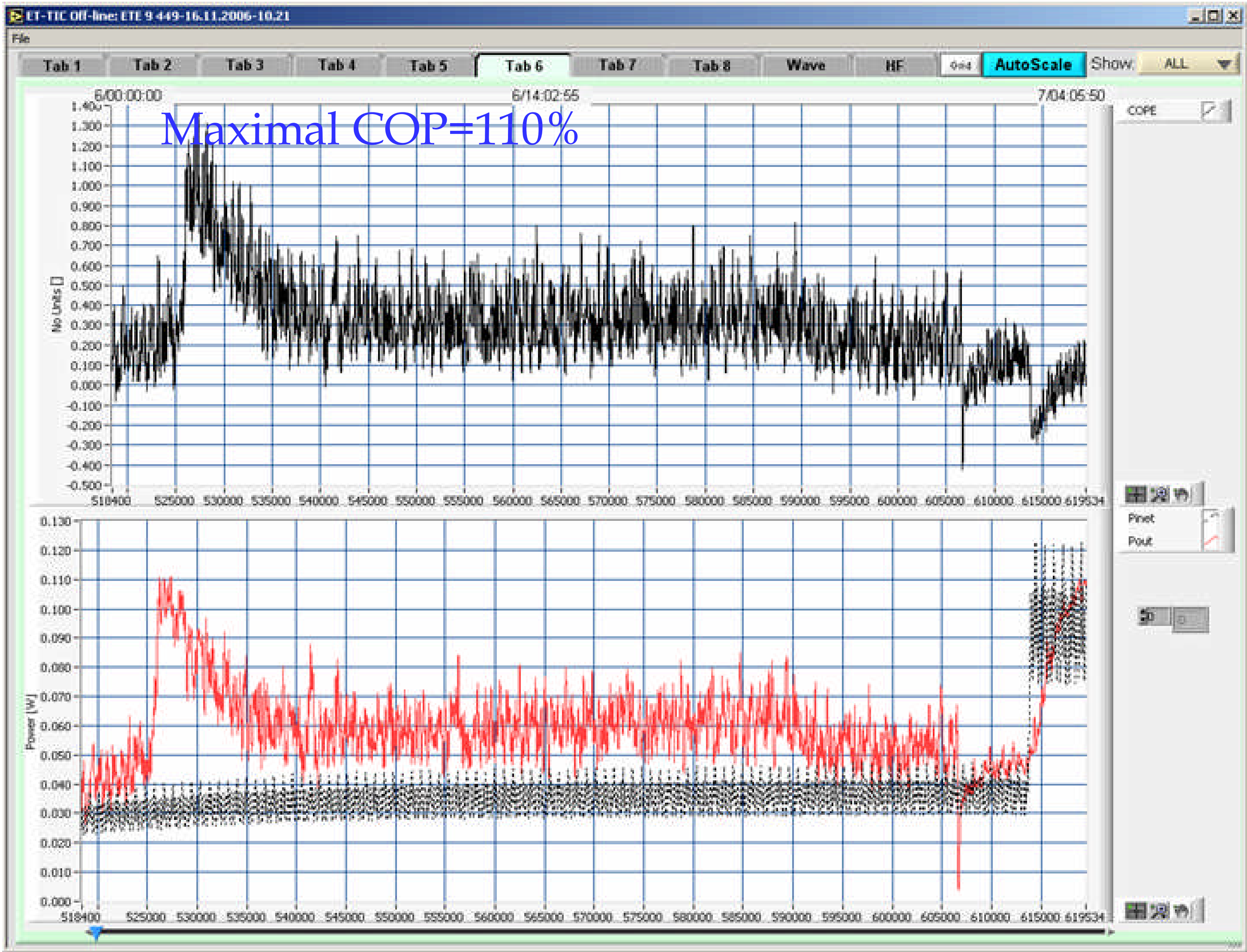


Estimated D/Pd atom ratio as a function of time after shut down of the electrolysis experiment: 1-Pd-5Ni alloy (Exp. #449), 2-Pd.

Exp.#449 – 5NiPd alloy

COP

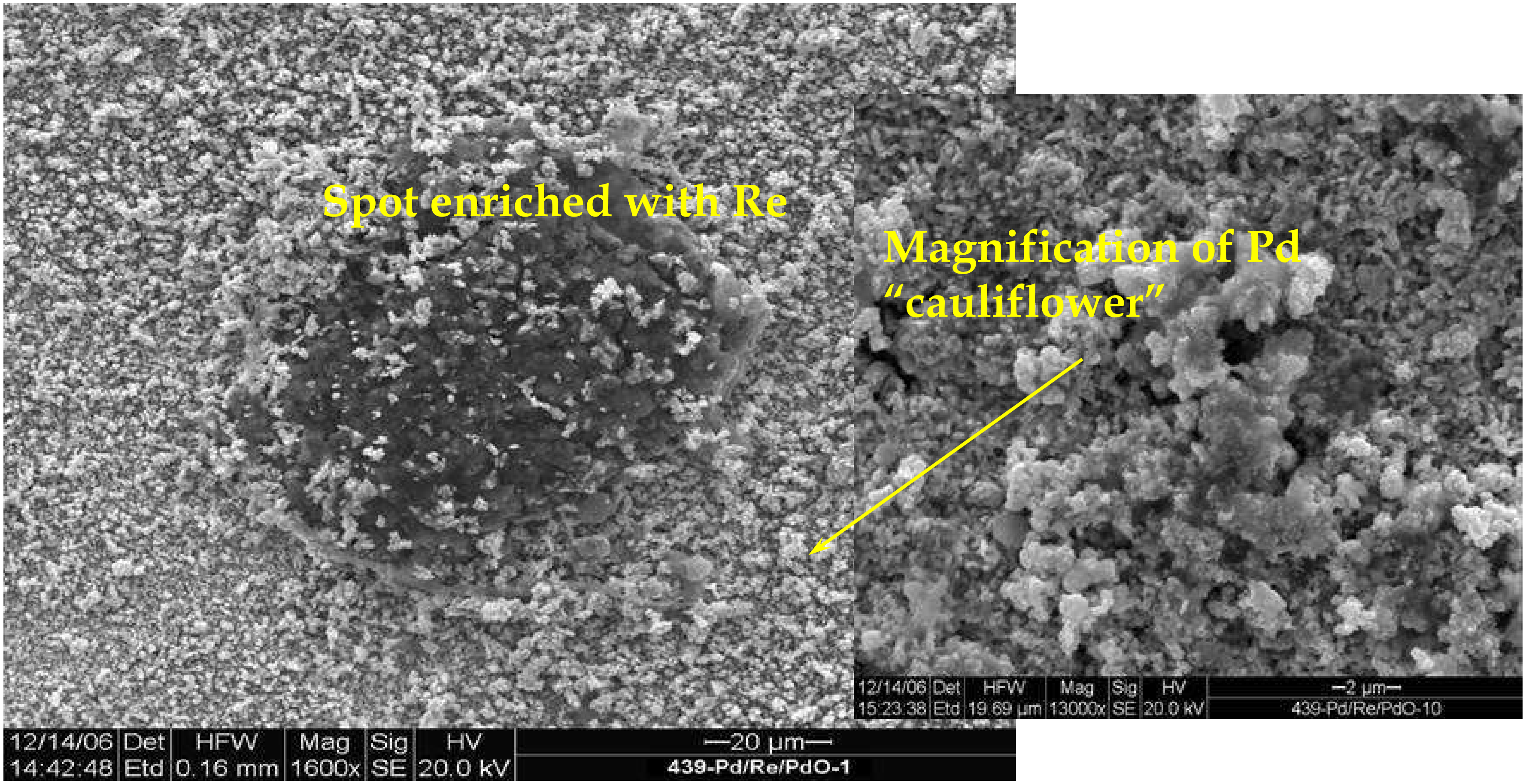
Power



Time

Multilayer foils - Pd/Me(MeO)/Pd

# of exp.	# giving EH	% giving EH
25	6	24%



Multilayer structure

Pd substrate 50 µm foil coated with 5-7 layers of PdO_x, Ni or Re alternating with 6-8 layers of Pd. Top layer is always Pd.

Exp.#375 – multilayer with Rhenium

Average COP=10%

Maximal COP=16%

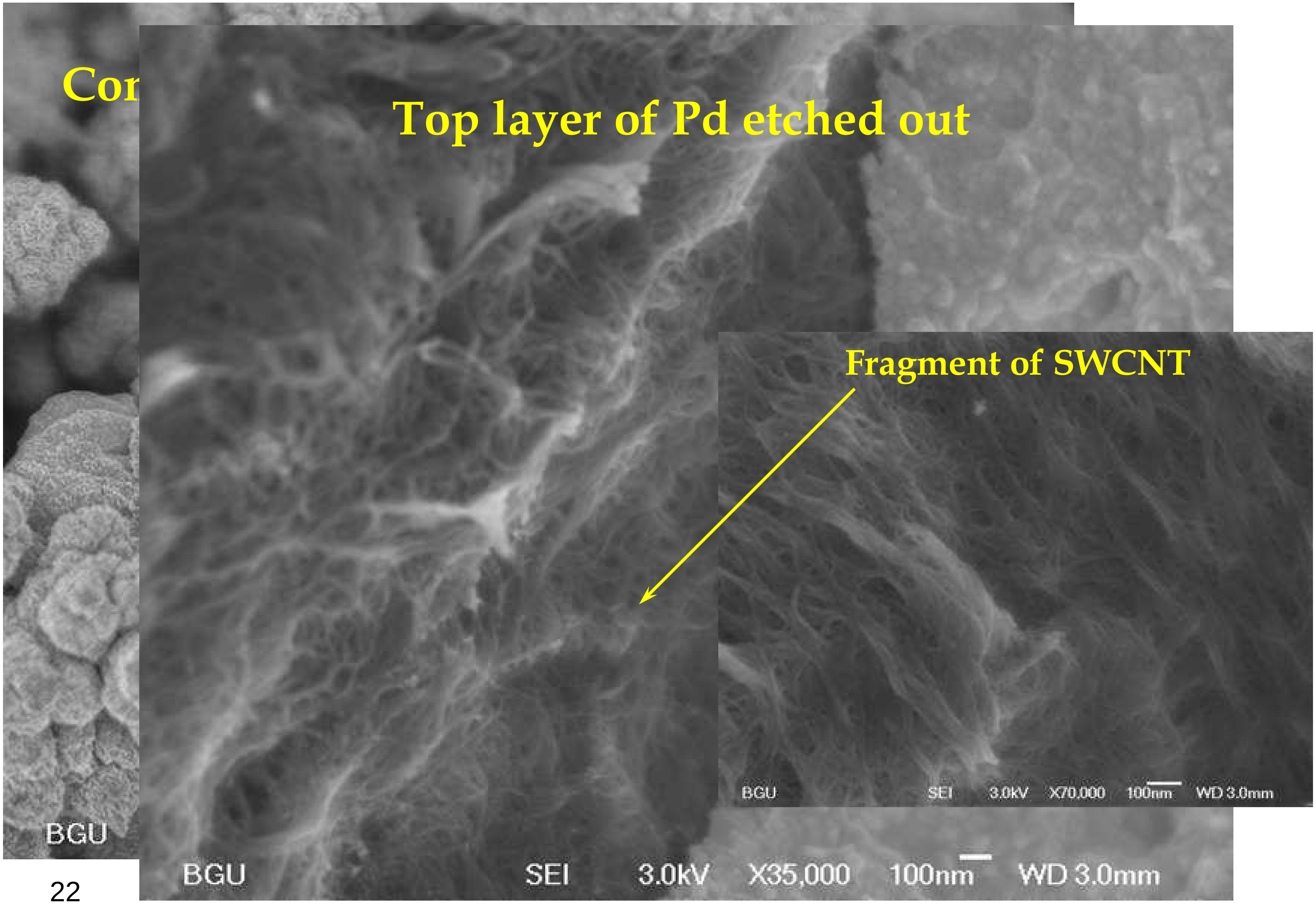
Power gain up to 2.5W

Energy

Power

Time

Composite Pd/Carbon Nano Tubes (SWCNT)/Pd

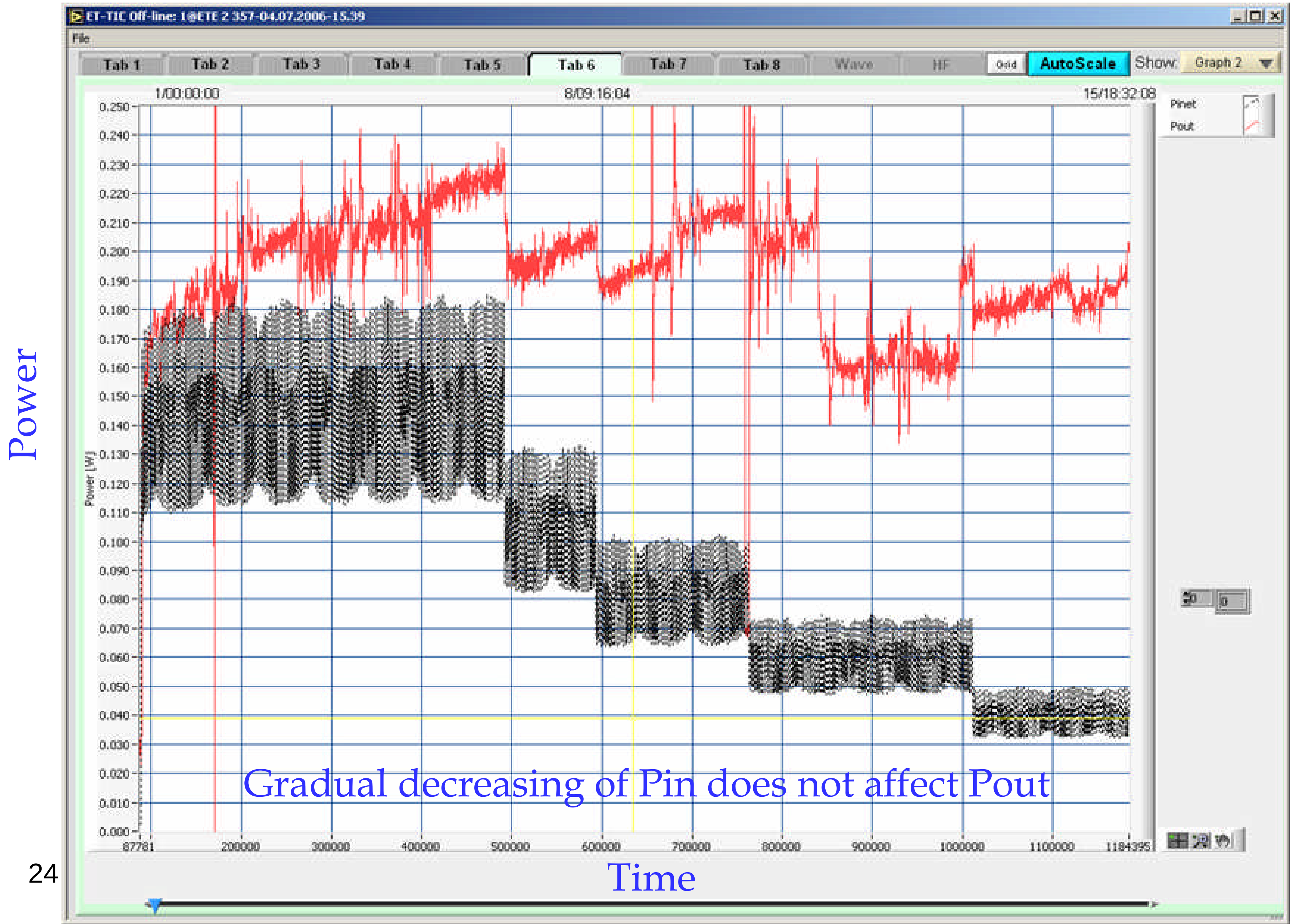


Single wall Carbon Nano tubes (SWCNT)

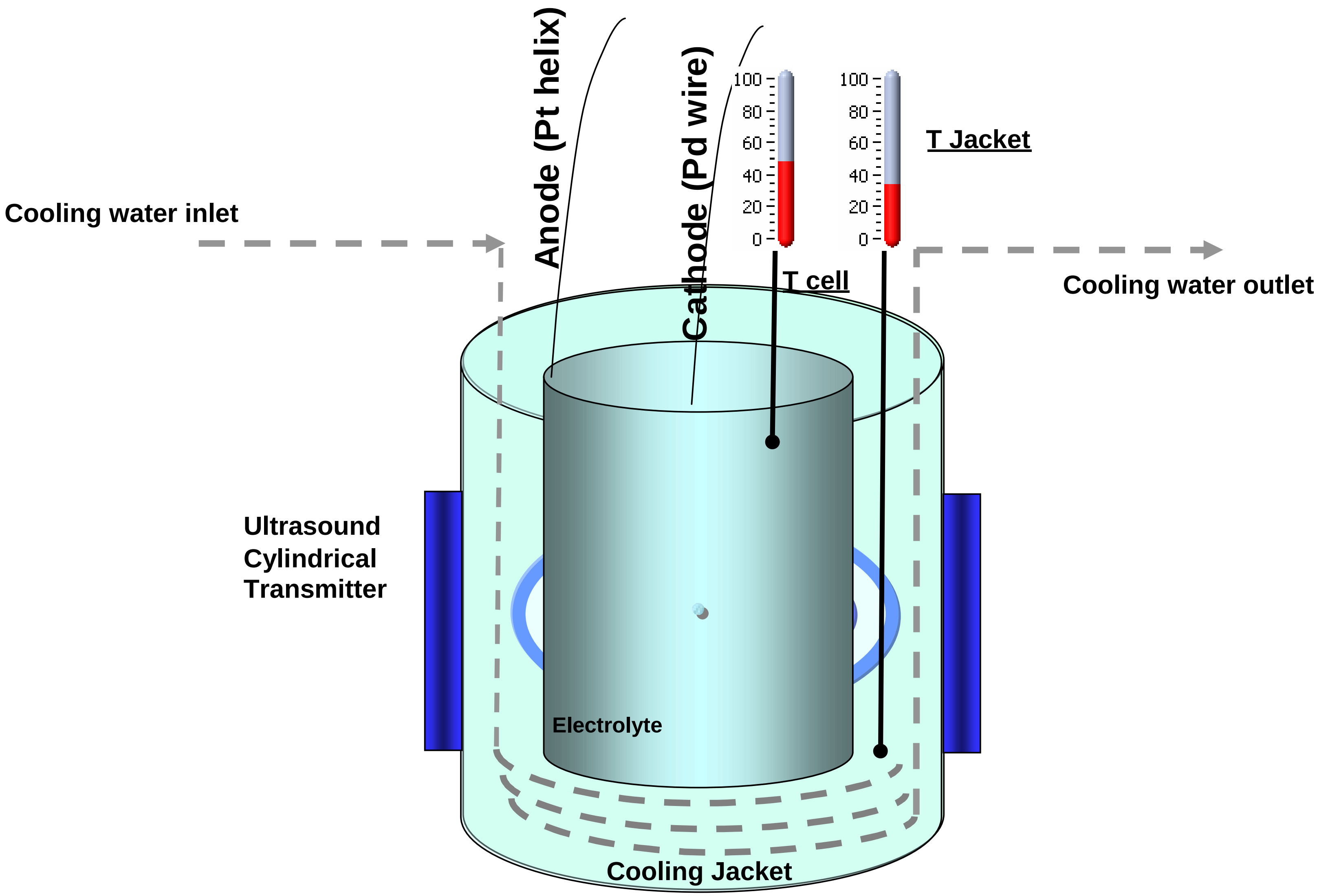
Series #	1	2	3	4	6
Manufacturer	CNI (old)	CNI (old)	Helix	Alfa Aesar	CNI (new)
Diameter, nm	1.1-1.2	1.1-1.2	1.1-1.2	1.1-1.2	1.1-1.2
Length, µm	1-2	1-2	0.5-40	10-20	1-2
Purity, %	95	95	90	>96	95
Adhesion	bad	good	very bad	excellent	excellent
Number of experiments	4	11	13	16(tested 12)	16(tested 8)
EH giving experiments	3	4	3	0	0
% giving EH	75	36	23	0	0

SWCNT opened by special etching procedure

Exp.#357 –Carbon nano tubes from 1st series

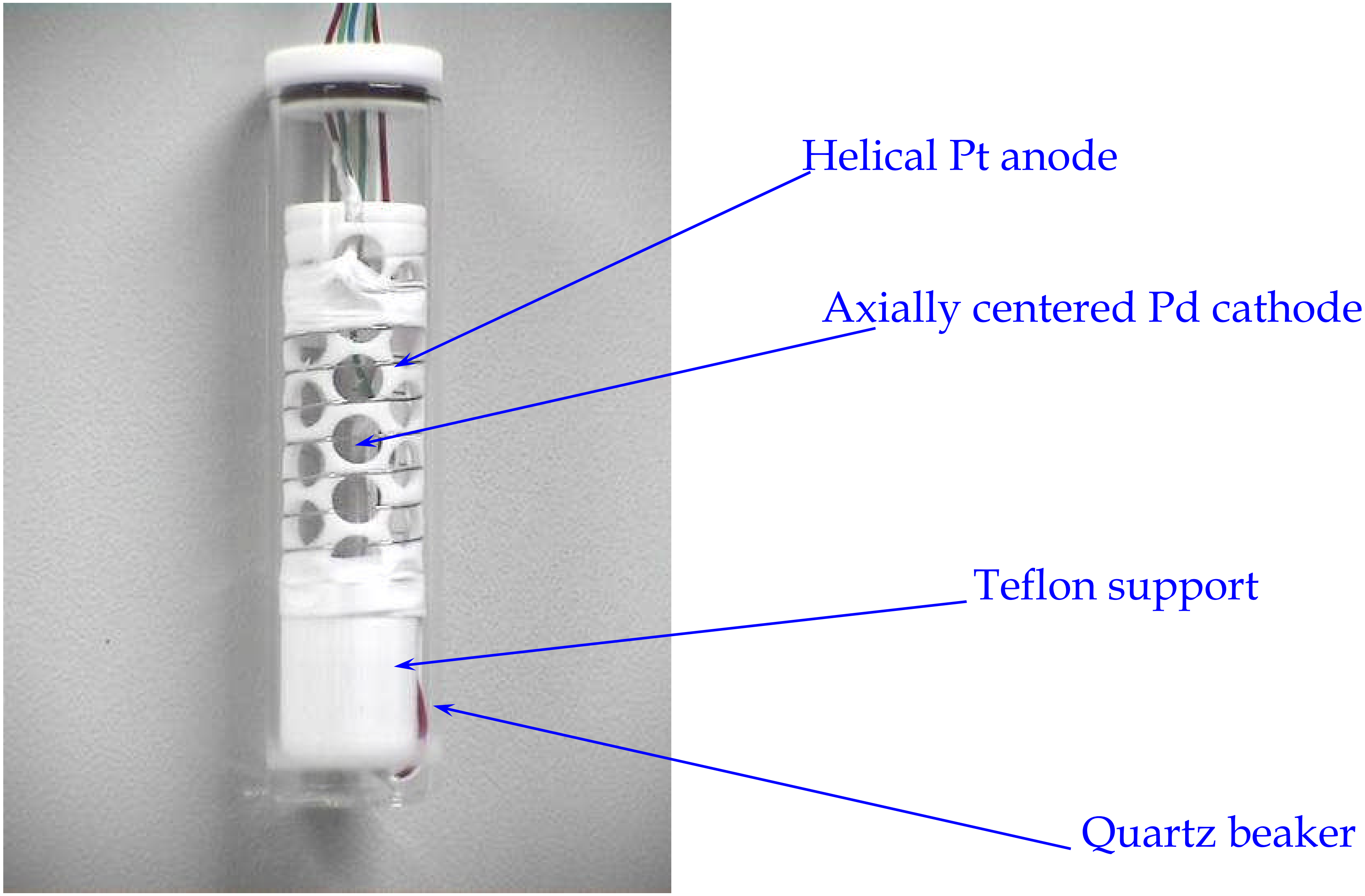


Electrolysis with ultra-sound excitation



Schematic view

Electrolytic cell for ultra-sound excitation setup A & B



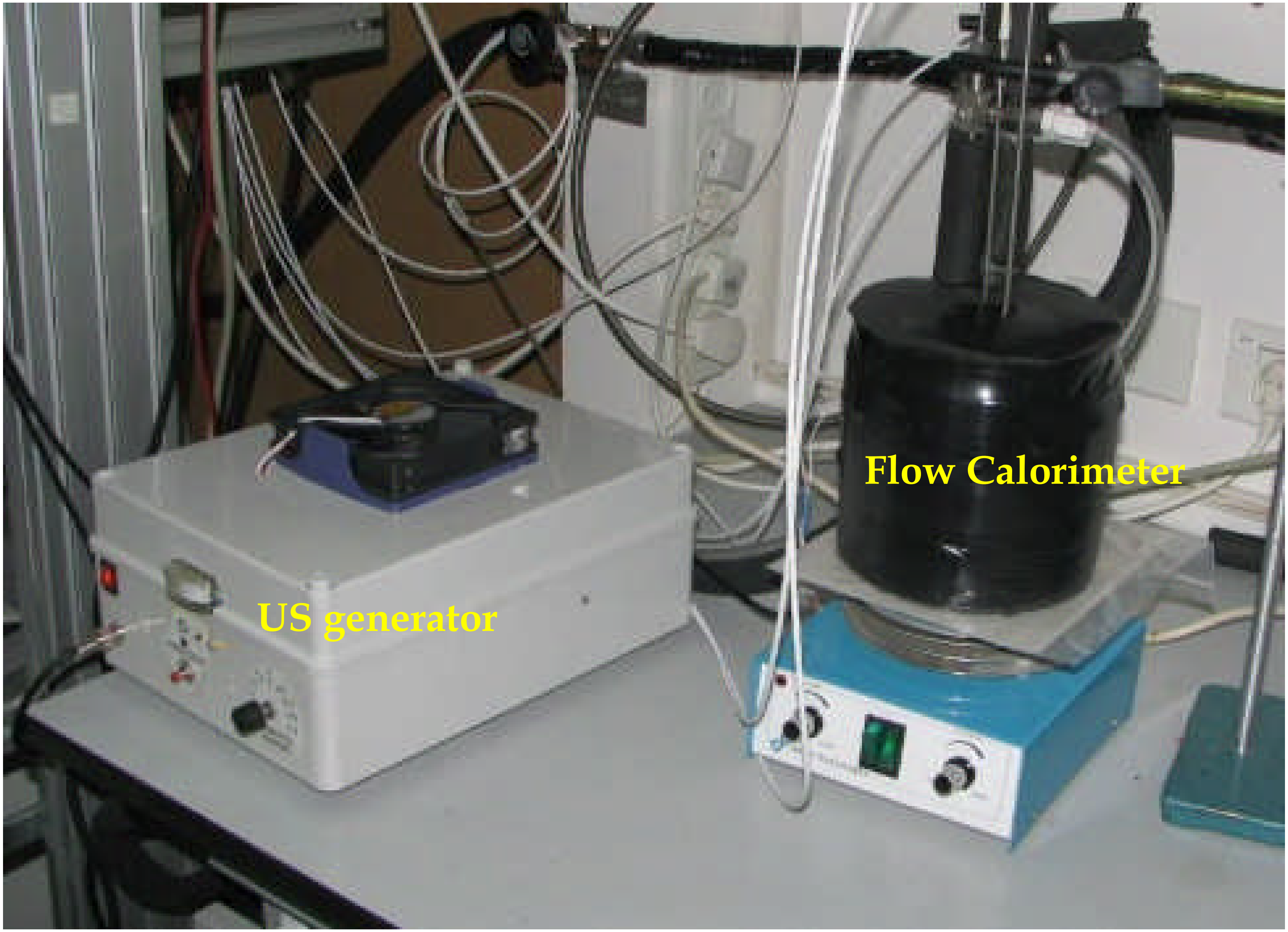
Electrolysis with ultra-sound excitation - Statistics

Setup type	Year	Calori meter	Thermo-stated	# of exp.	# giving EH	% giving EH
A	2006	no	no	6	4	**67**
B	2006	yes	no	13	6	**46**
	2007	yes	no	5	5	**100**
C	2006	yes	yes	2	0	**0**
	2007	yes	yes	3	2	**67**
Total				**29**	**17**	**59**

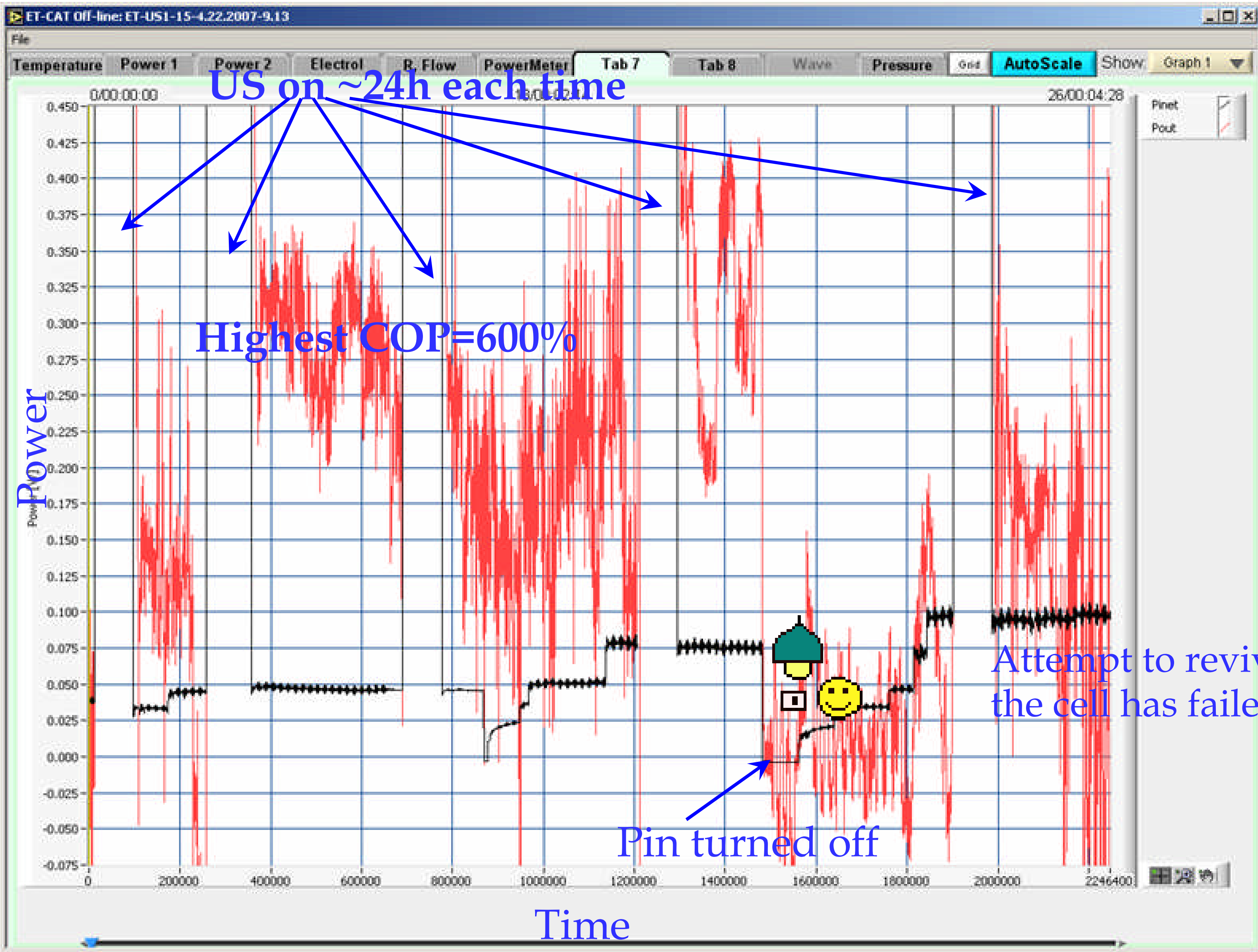
Observations :

- extremely high loadings (R/R_0 = 1.47-1.43) applying very low current densities (not higher than 10 mA/cm2).
- ability to stay loaded in open air during 1-12 weeks (stable β phase)

Setup with flow calorimeter (Setup B)



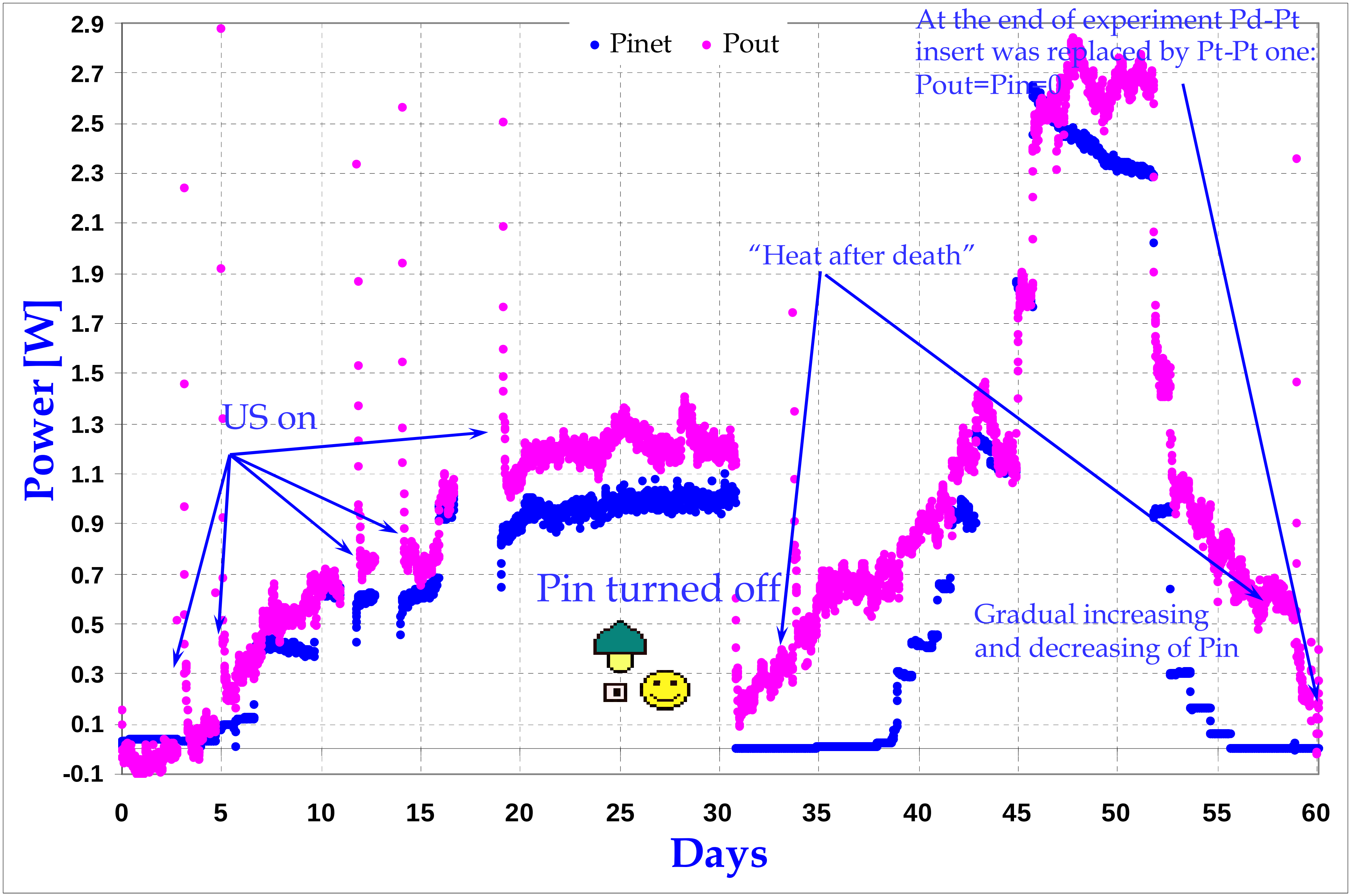
Exp.#ETUS1-15; calorimeter not thermo-stated (setup B)



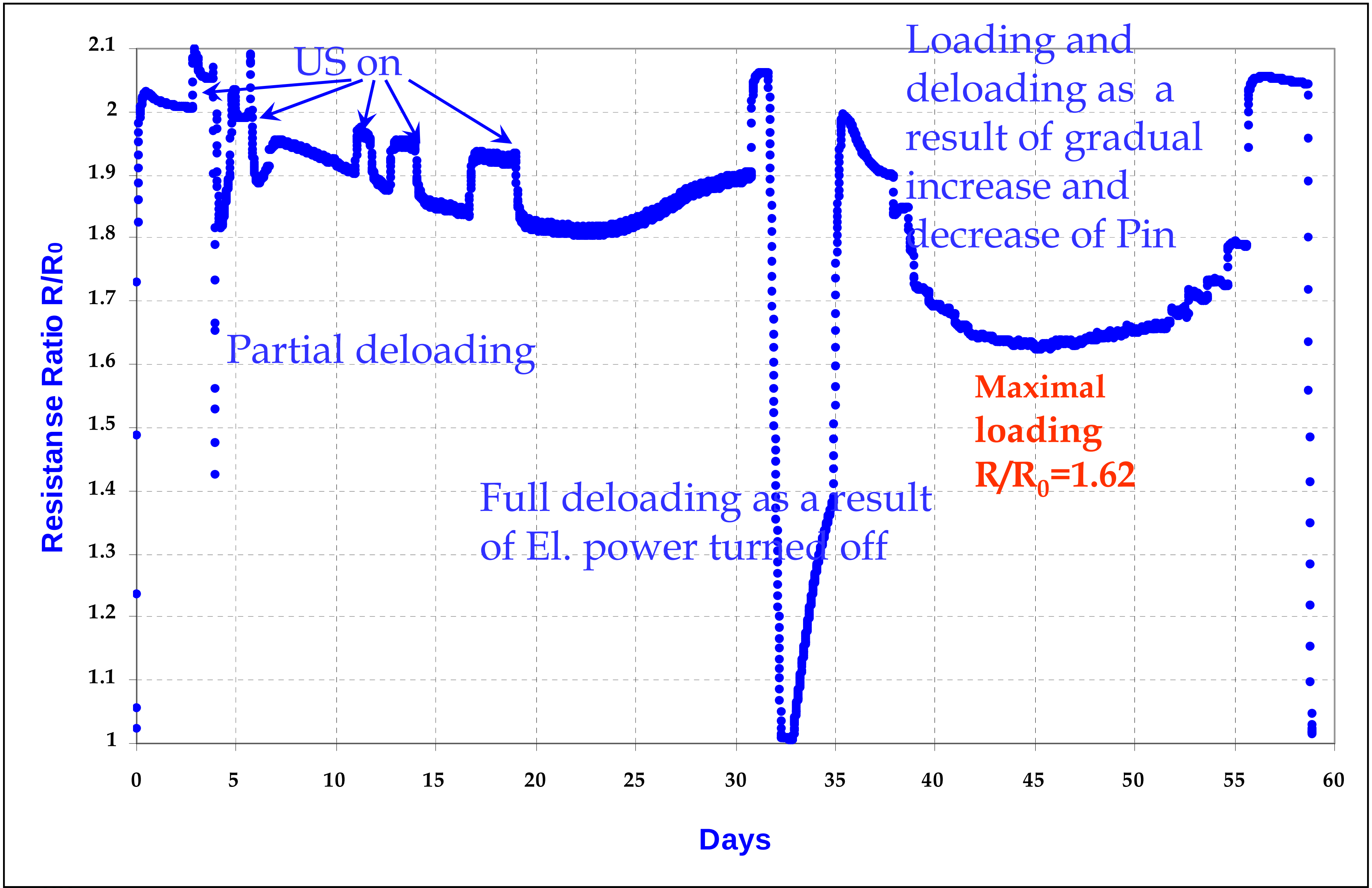
26 days of run

Thermo-stated E-US cell with flow calorimeter (Setup C)

Exp.#ETUS3-5 in Setup C – "heat after death"



Experiment ETUS3-05

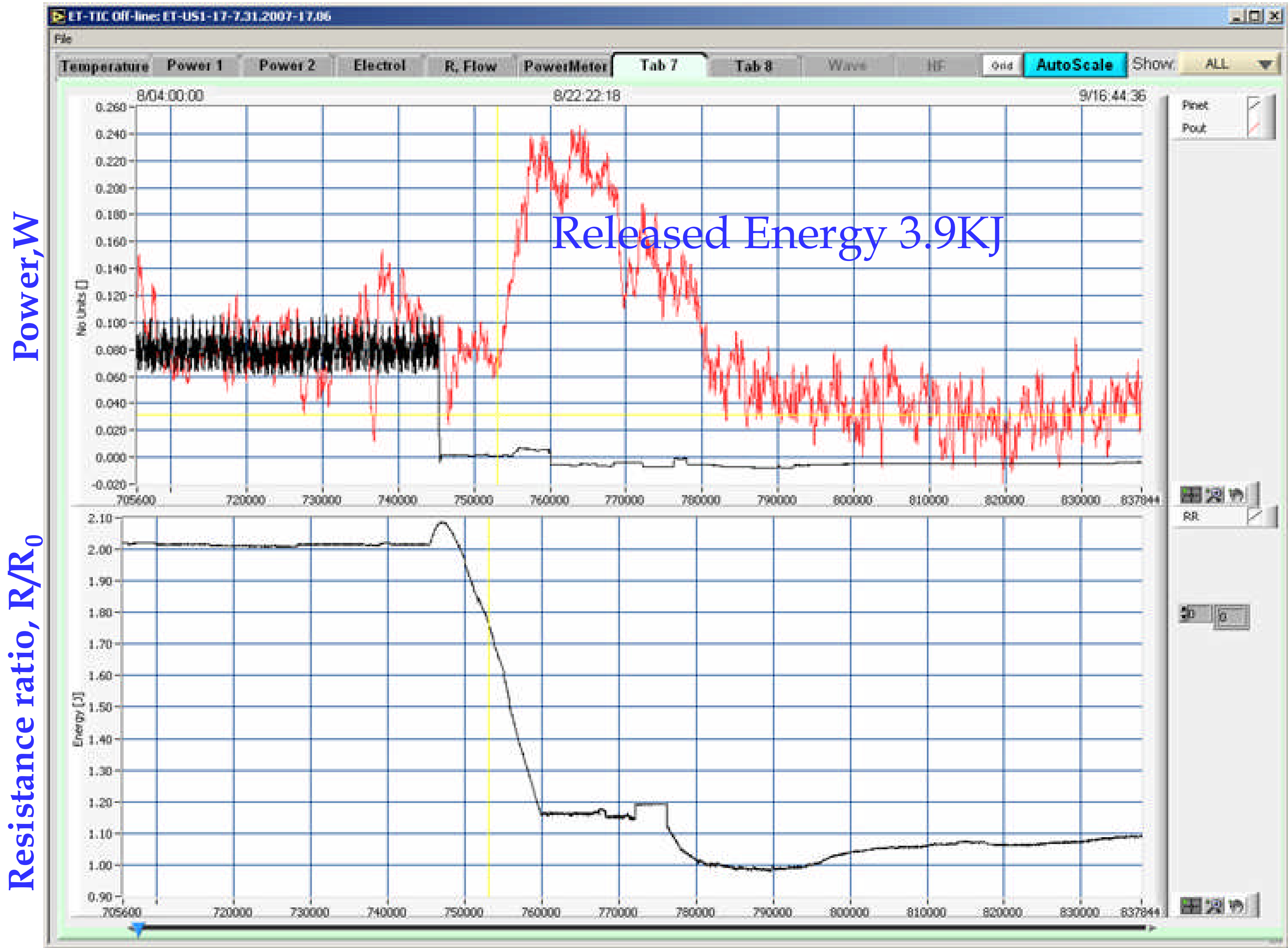


Loading Path

The most recent experiment ETUS3-6; Setup C

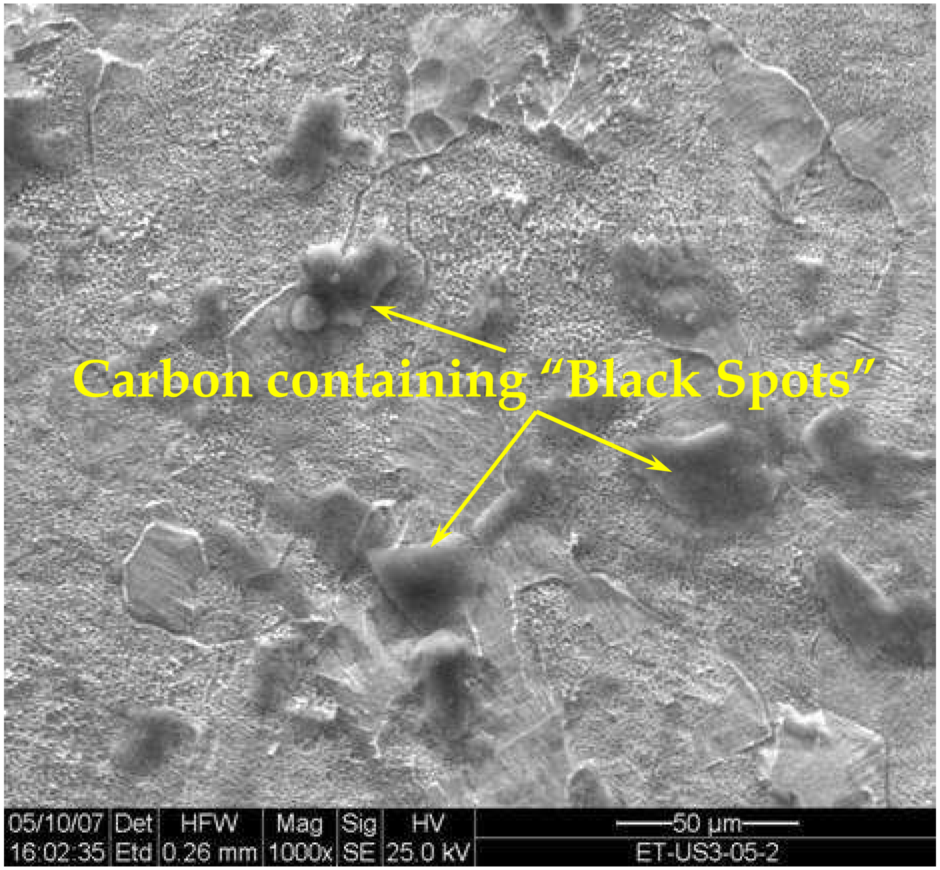
32 days of run

Exp.#ETUS1-17; calorimeter not thermo-stated (setup B)



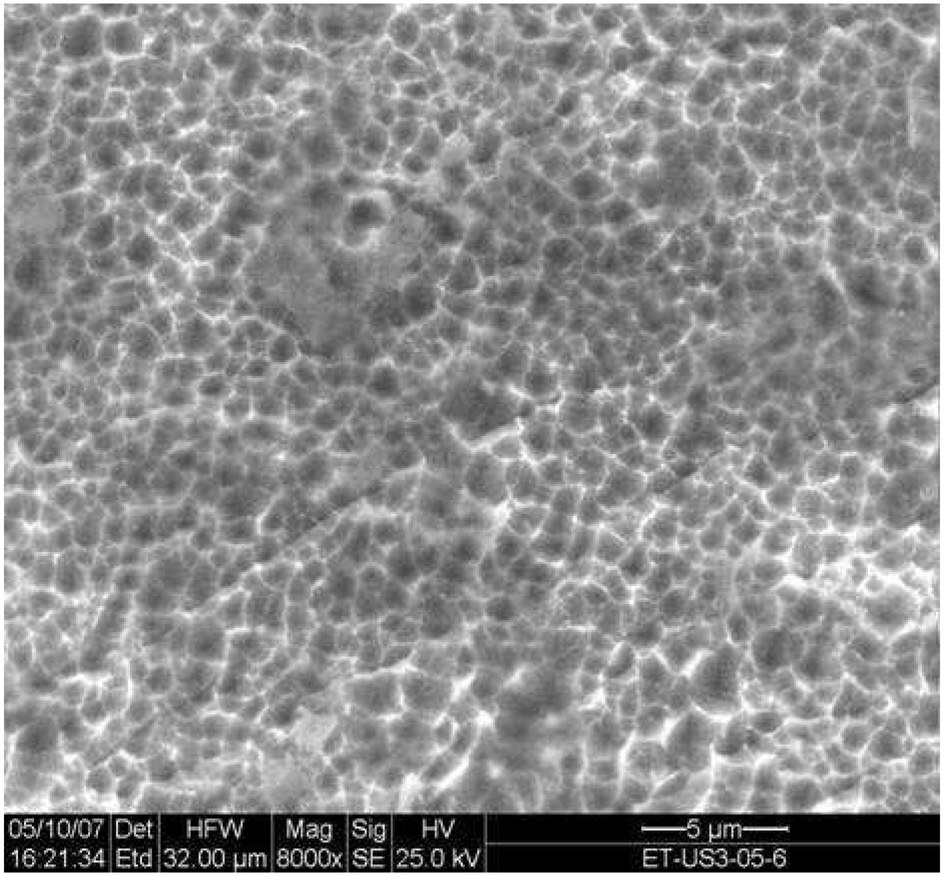
"Heat after death" – heat generation during 11 h after termination of loading

ETUS3-6 surface after experiment SEM image magnification x1000

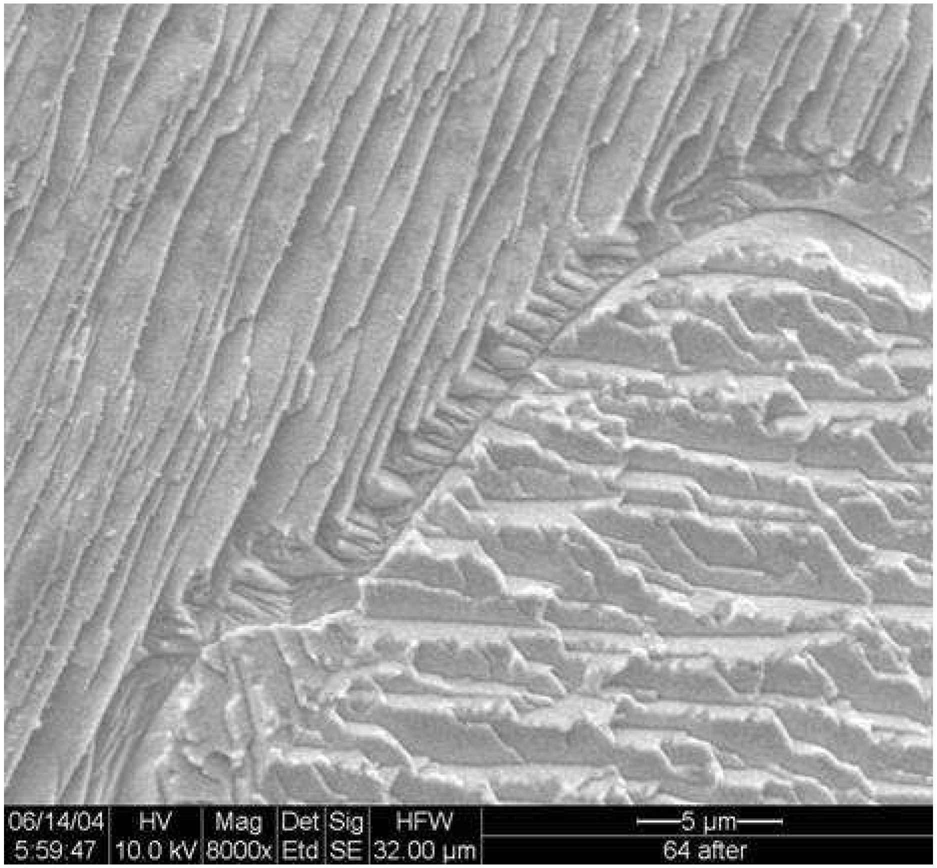


Non-metallic contaminations on the cathode surface

Comparison of ETUS3-6 and ETE-64 (no US) surface after experiment – both gave EH SEM image magnification x4000 and x8000



Strongly pitted surface



Plastic deformation

Conclusions

- Highest reproducibility is obtained with ultra-sound excitation. Need to optimize application of US.
- First series of Pd/SWCNT/Pd sandwich targets had high reproducibility. Need to find comparable SWCNT.
- Also promising are Pd foils that underwent etching using glow-discharge with deuterium
- Significant "Heat-after-Death" was obtained in 2 experiments with ultra-sound excitation and with Pd/SWCNT/Pd sandwich targets. **It is suggested that SuperWaves exposure could create a long-term effect (memory) in the cathode in the form of spontaneous lattice oscillations that result in the heat release.**

Acknowledgement

This work was funded by Mr. Sidney Kimmel