ICCF11 TUTORIAL

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SEARCH FOR OPTIMUM CONDITIONS TO PRODUCE EXCESS HEAT FROM THE ELECTROLYSIS OF HEAVY WATER WITH A PALLADIUM CATHODE

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Electrolysis Cell

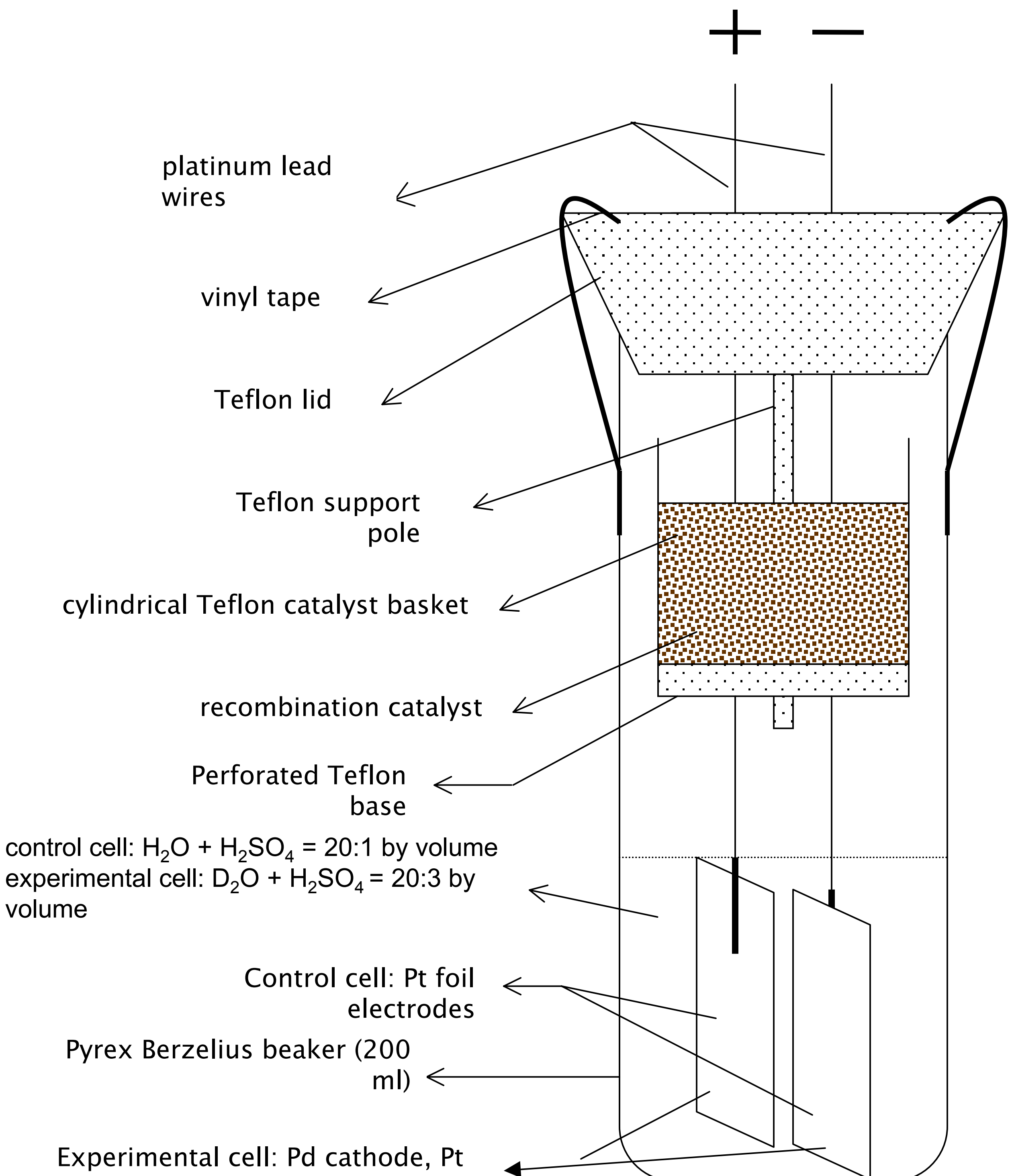


Figure: cell

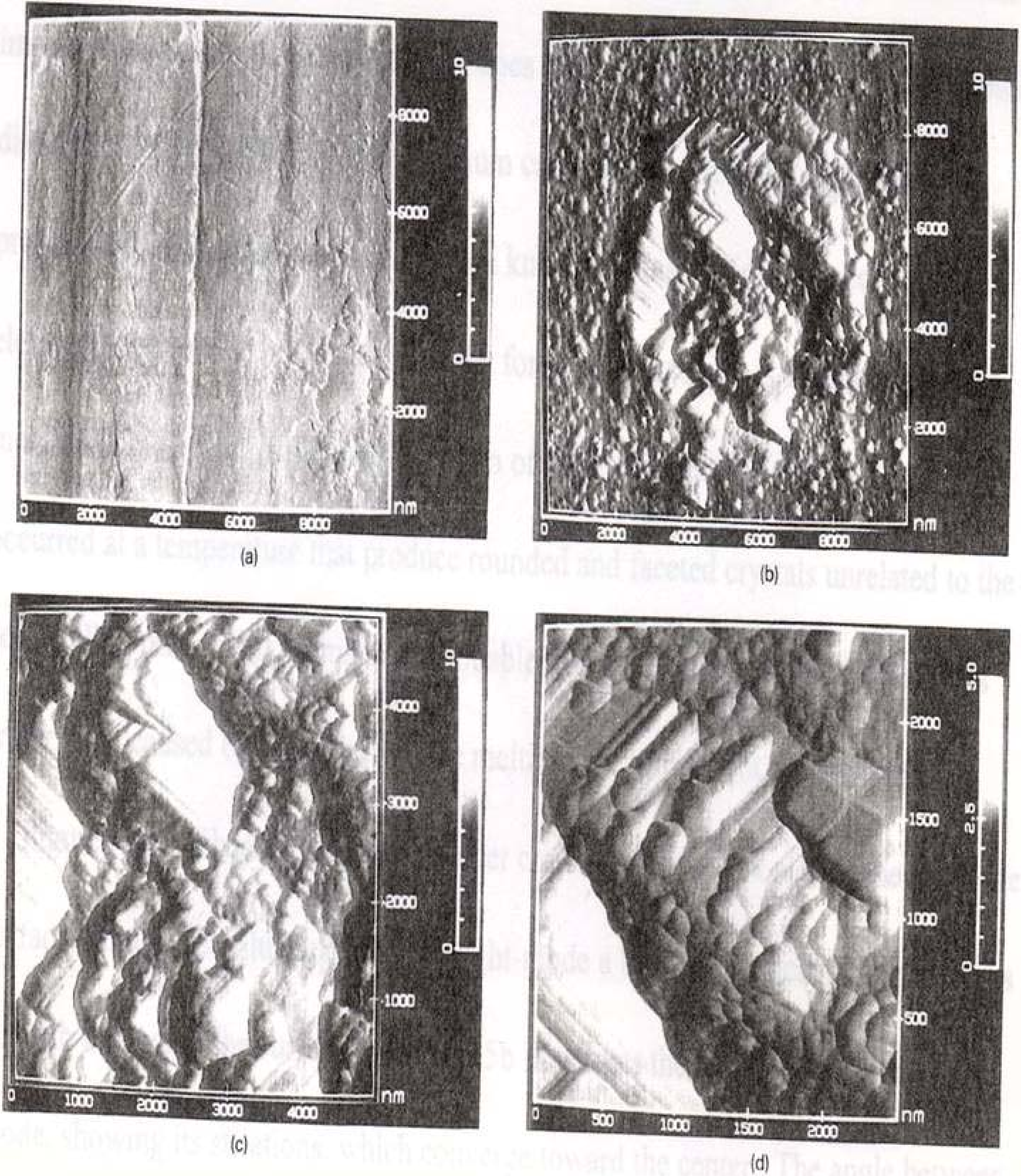


Figure 13. AFM images of a) Pd foil surface after cold rolling (the vertical lines resulted from contact with the steel rolls); b) Pd cathode surface after electrolysis for 12 minutes; c) and d) are enlargements of surface pit in (b) to show the rounded and faceted features.

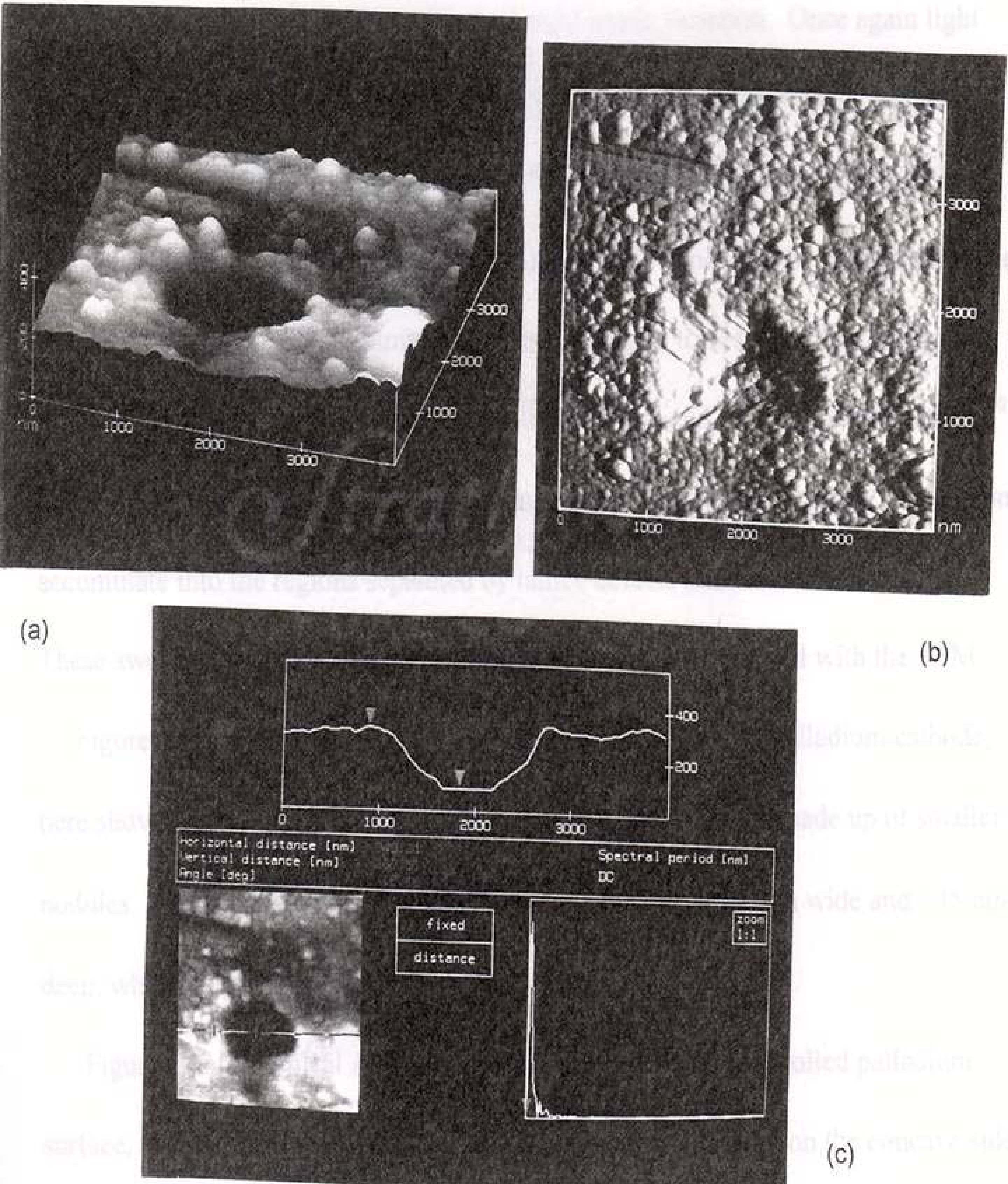
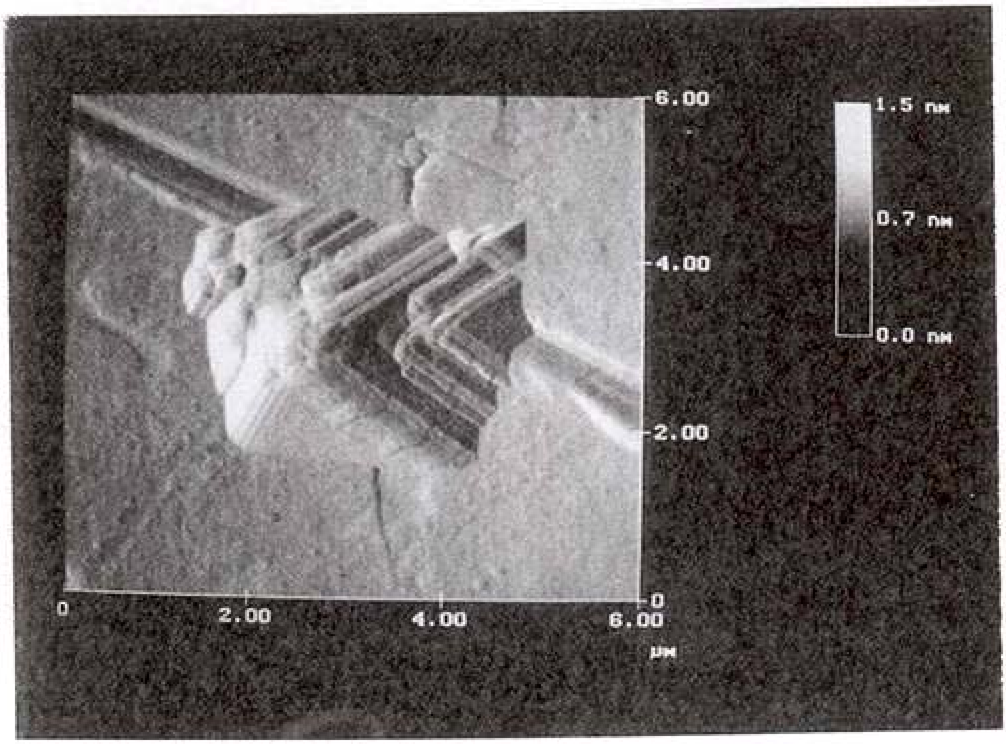


Figure 15. a) A bowl-shaped cavity in Pd cathode, illustrated a) in the height-mode b) in the force-mode, showing striations that converge into its center, and c) contour of the crater. The crater drops > 280 nm vertically from its rim.

(a)



(b)

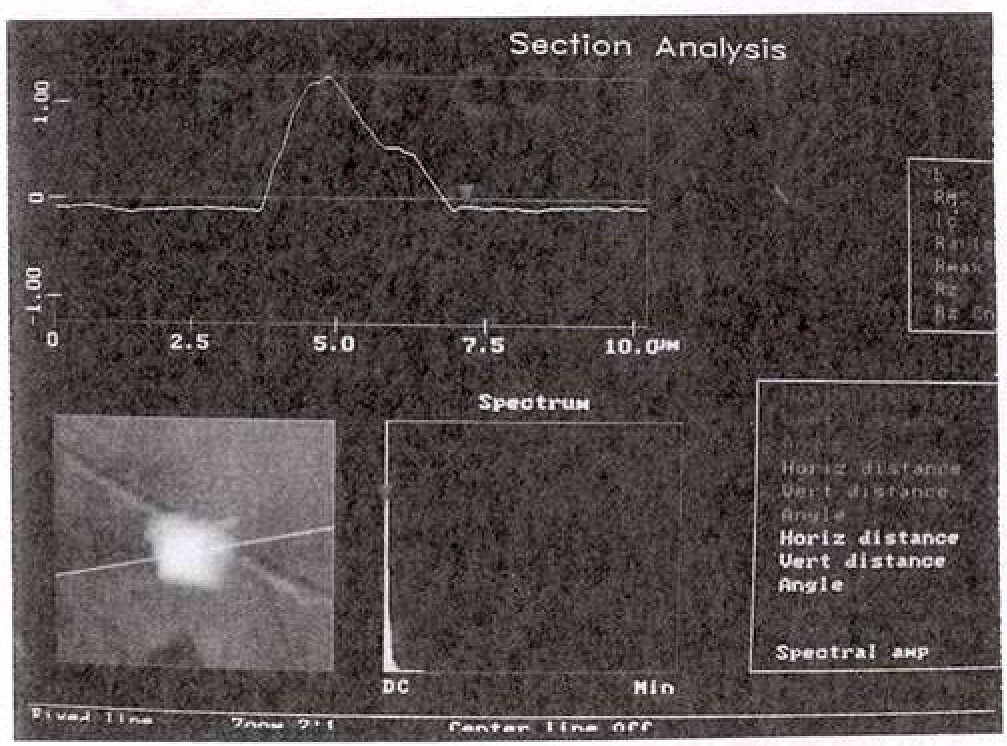


Figure 22. An AFM force-mode image a) of the palladium cathode side facing away from the anode, electrolyzed for a total of 105 seconds. The asperity seen here appears to be from melting and recrystallization. The angles of the facets suggest that these are traces of {111} planes. The section analysis b) indicates that this feature rises about 1 µm above the surrounding surface.

SECONDARY ION MASS SPECTROSCOPY (SIMS)

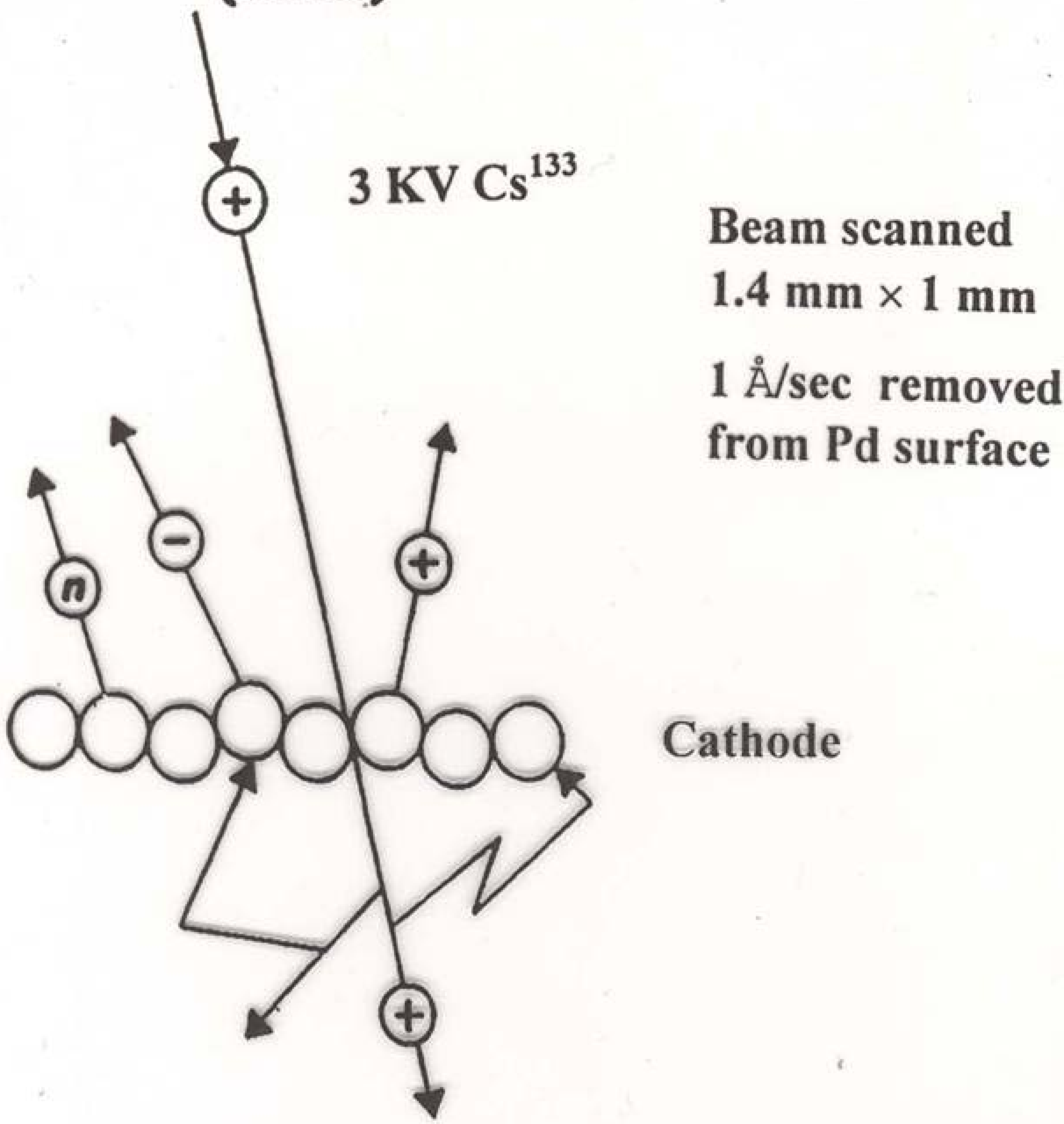


Figure 29. SIMS is a procedure that bombards a small area of the Pd surface with a primary beam (Cs133). Surface atomic layers are sputtered off, and the mass of the ions from the resulting sputtered particles are analyzed using a mass spectrometer to provide elemental and isotopic identification.

RELATIVE ABUNDANCES AND WEIGHTS OF NATURALLY OCCURING ISOTOPES

Elem.	AMU	Isotopic Comp. (at.%)
Pd^{102}	101.905634	1.020
Pd^{104}	103.904029	11.14
Pd^{105}	104.905079	22.33
Pd^{106}	105.903478	27.33
Pd^{108}	107.903895	26.46
Pd^{110}	109.905167	11.72
Ag^{107}	106.905092	51.839
Ag^{109}	108.904757	48.161
Cd^{106}	105.906461	1.25
Cd^{108}	107.904176	0.89
Cd^{110}	109.903005	12.49

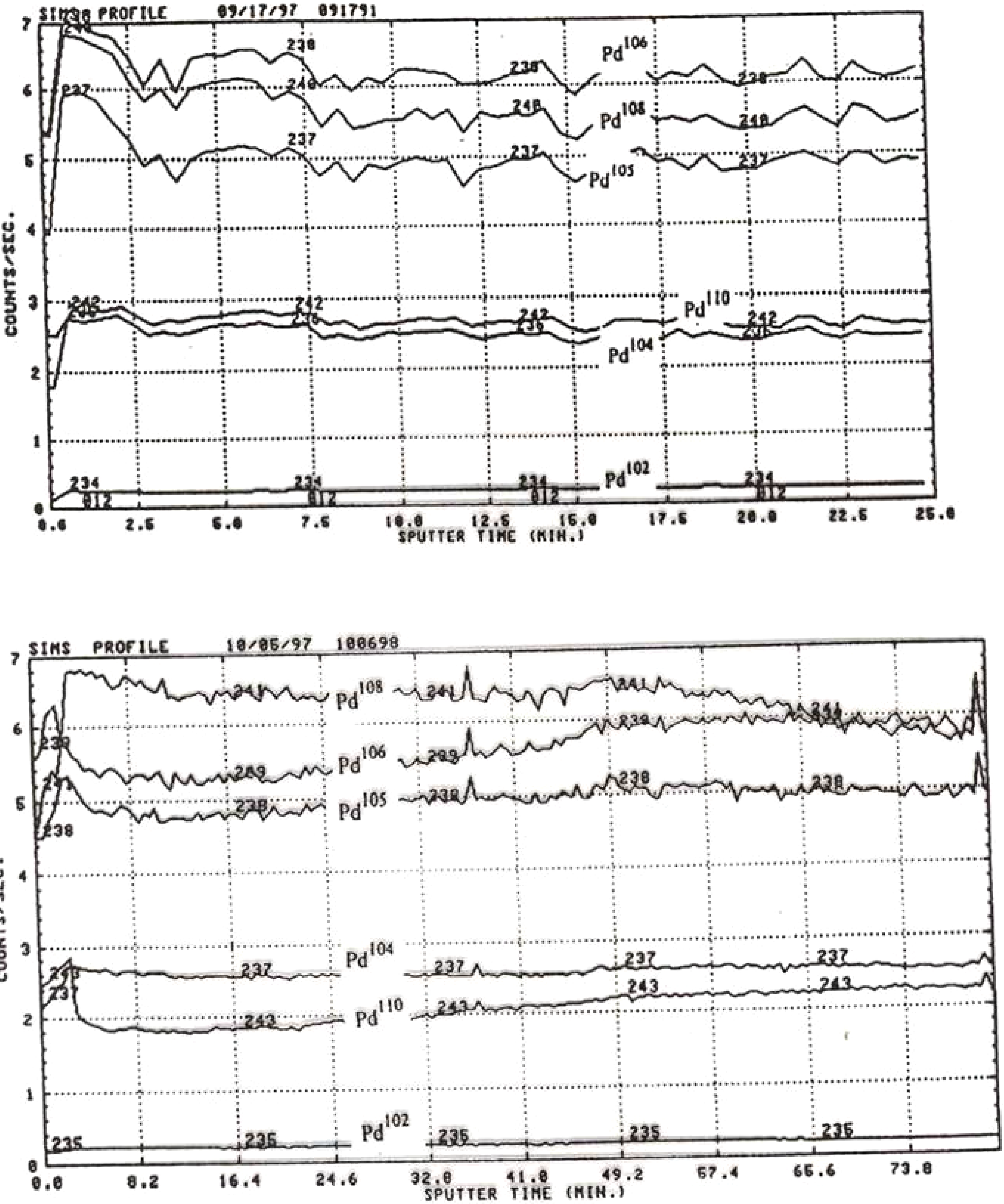


Figure 1. SIMS profile of the six palladium isotopes for a region of the palladium sample not electrolyzed (top), and a region of the six minute heavy water electrolyzed sample (bottom). The latter shows isotopic inversions of Pd^{108} with Pd^{106}, which merge after ~65 minutes sputtering. Also Pd^{110} and Pd^{104} are inverted.

Energy Dispersive X-Ray Spectrometer

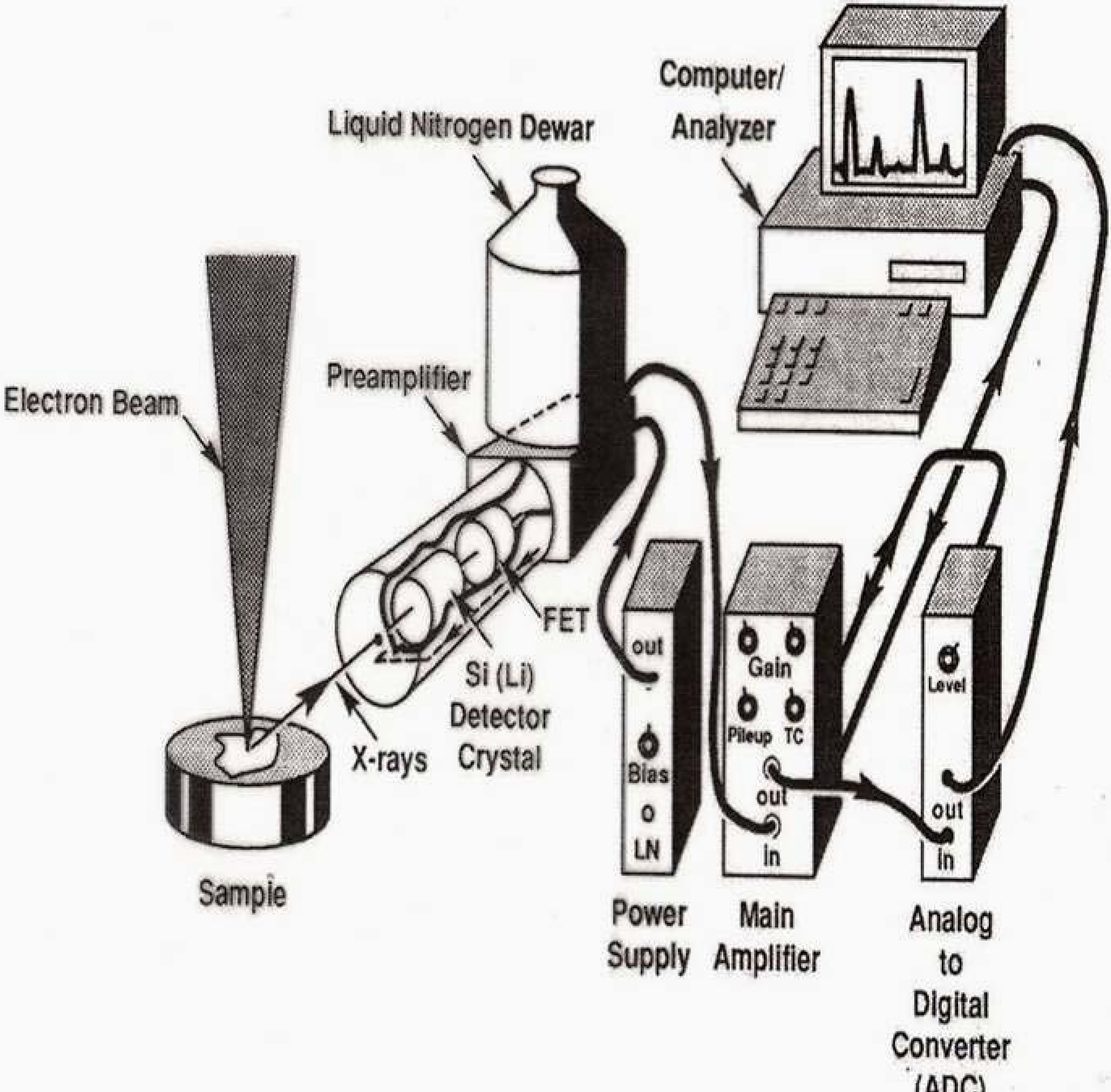
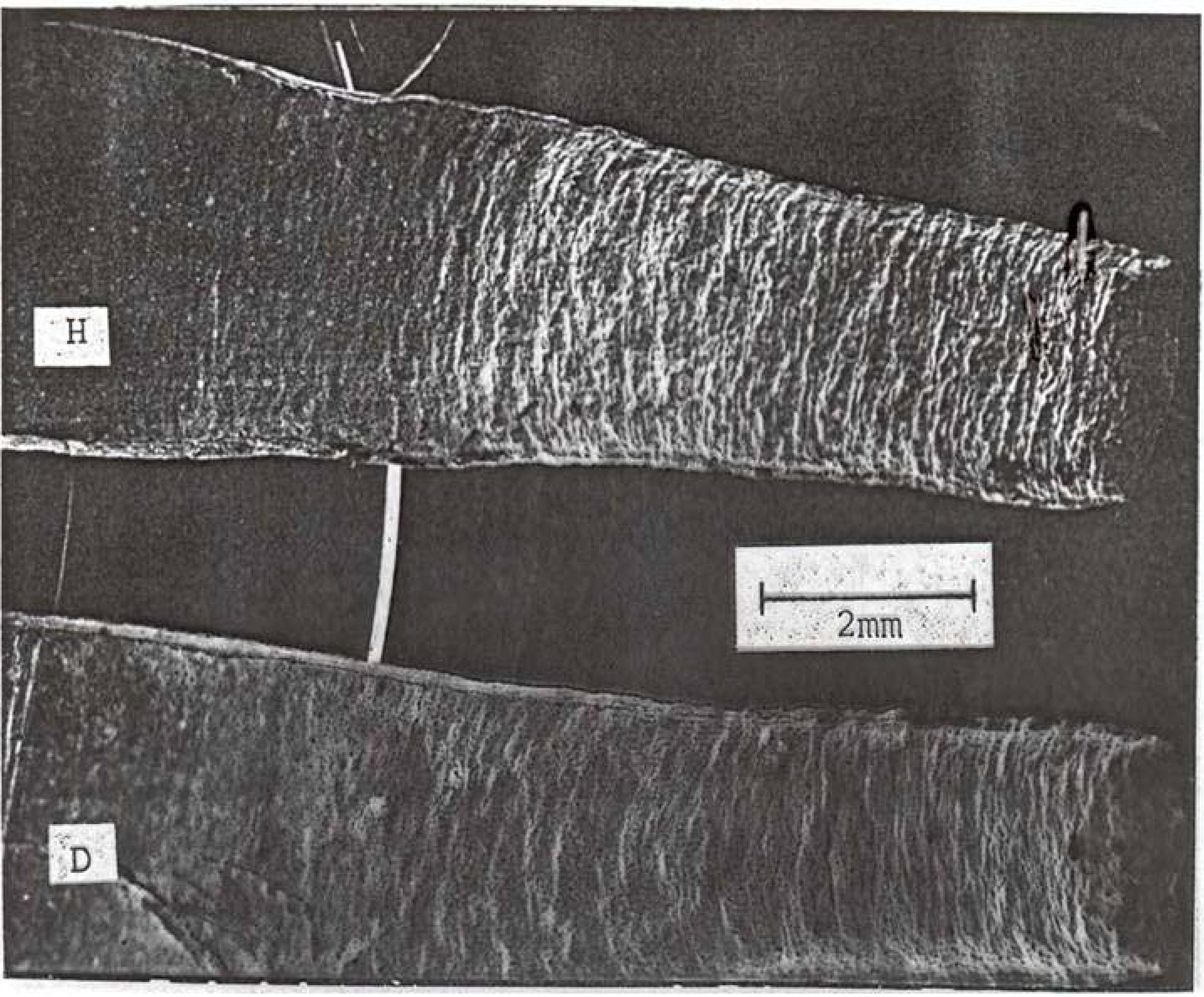


Figure 5.20. Schematic representation of an energy-dispersive spectrometer and its associated electronics.



Pd cathodes 0.35mm thick, after electrolysis for about 400 hours

H - electrolyzed in H_2O – H_2SO_4
D – electrolyzed in D_2O – H_2SO_4

0.1 to 0.2 watts excess power produced by D_2O cell compared with H_2O cell during first 300 hours of operation

0.1 to 0.2 watts excess power produced by H_2O cell compared with D_2O cell during final 100 hours of operation

Fig. 2. Enlargement of lower right corner of H_2O cathode in Fig. 1.

the electrolyte where it occurs due to slow dissolution of the Pt anode. Au, however, is not expected to arise from a pure Pt anode. Nor is it expected to occur inhomogeneously as an impurity in Pd because Au and Pd are completely miscible in the solid state[3].

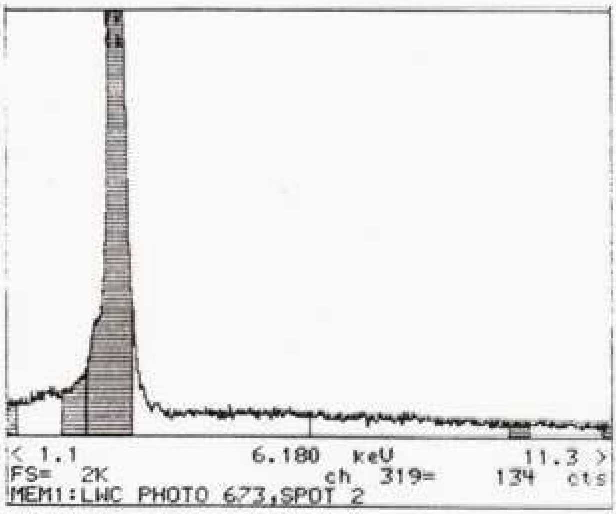


Fig. 3. EDS spectrum from region A of the H_2O cathode shown in Fig. 2.

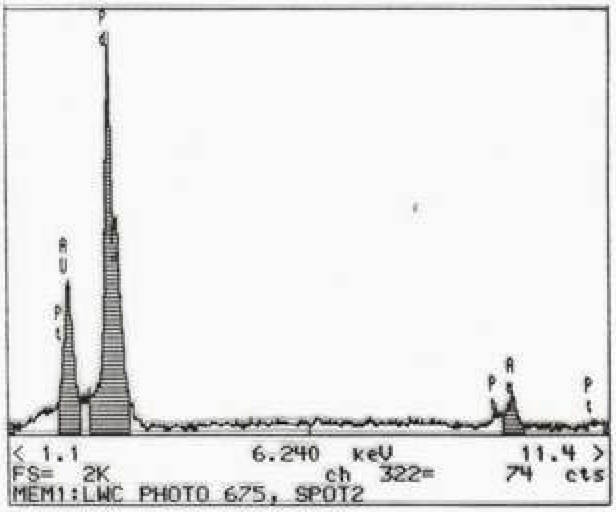


Fig. 4. EDS spectrum from region B of the H_2O cathode shown in Fig. 2.

Assume that the following fusion reaction occurs:

$$D^+ + D \rightarrow {}^3He\ (0.82\ MeV) + n(2.45\ MeV)$$

Subsequently, the neutron produced in this reaction is absorbed by a Pt atom on the surface of the Pd electrode. The energy of the neutron is converted to heat, and the Pt atom decays to Au by the following reaction:

$${}^{196}Pt + n \equiv {}^{197}Pt \equiv {}^{197}Au$$

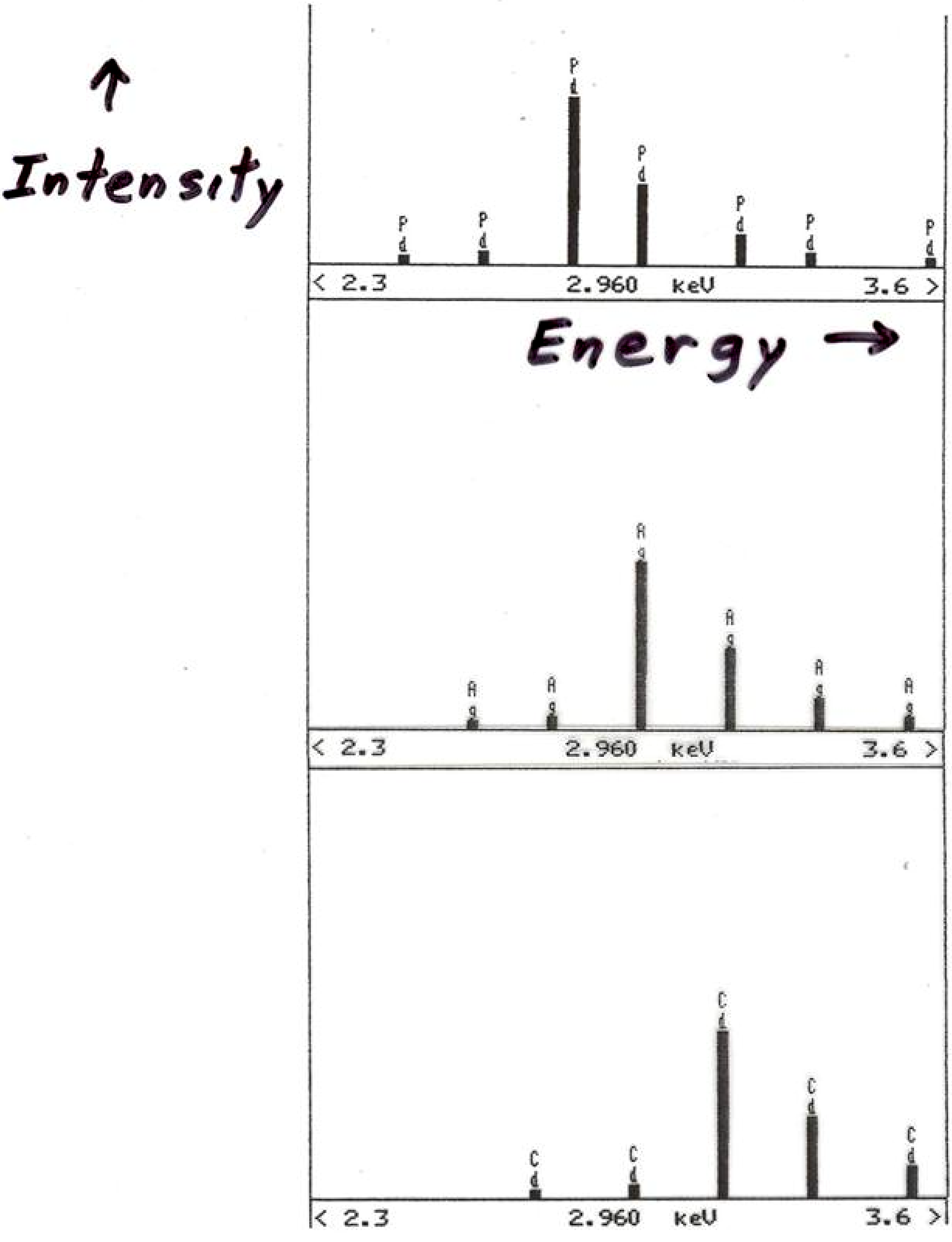
^{197}Pt is an unstable isotope, with a half life of 80 min. It yields an orbital electron, thus becoming ^{197}Au (stable).

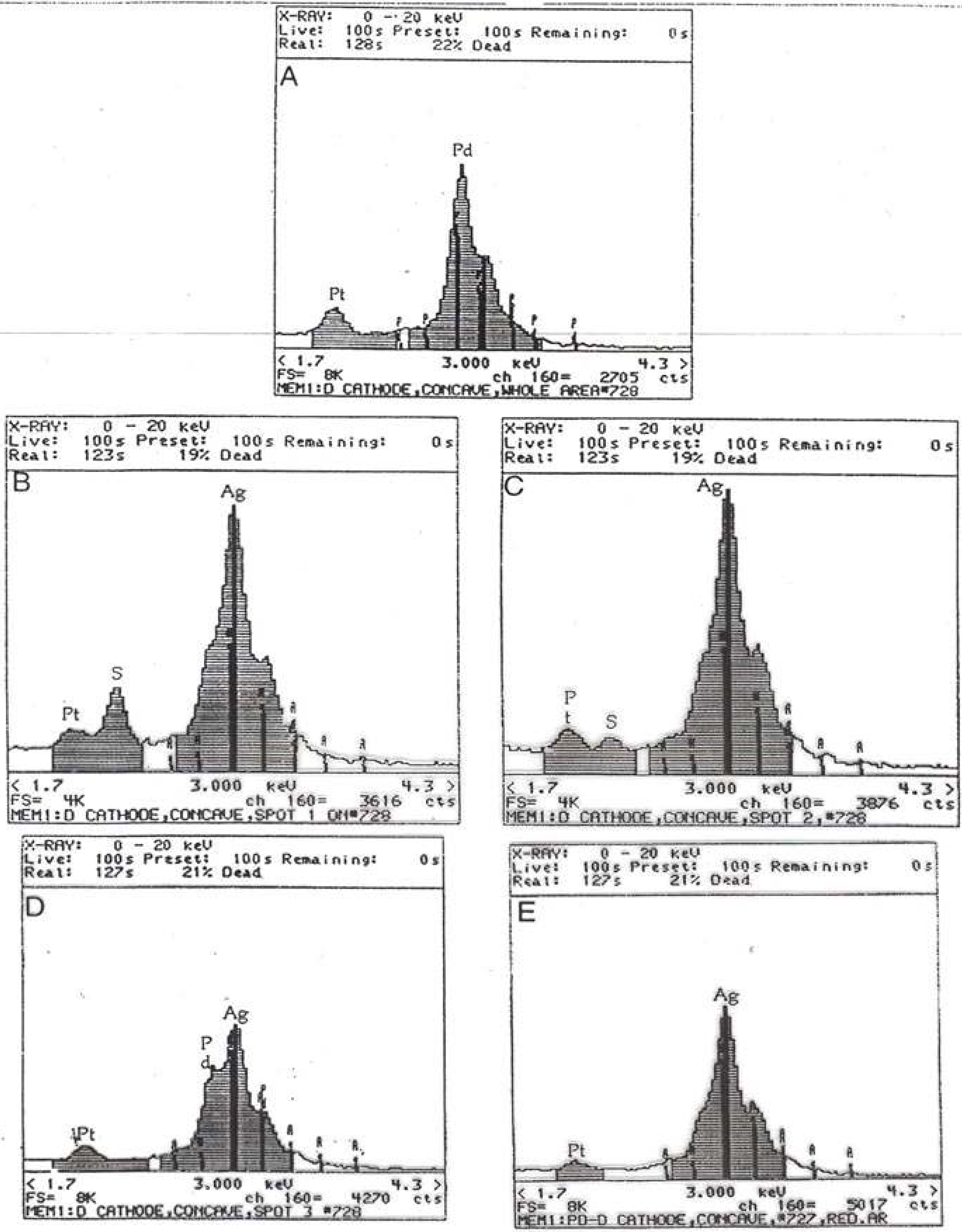

3
2
1
4
10 µm
20kv 728

Characteristic Peaks for Pd, Ag, and Cd

La - most intense

Lb - about one-half La intensity





A: Spectrum from area of photograph in Figure 3

B: Spot 1, Figure 4 C: Spot 2, Figure 4

D: Spot 3, Figure 4 E: Spot 4, Figure 4

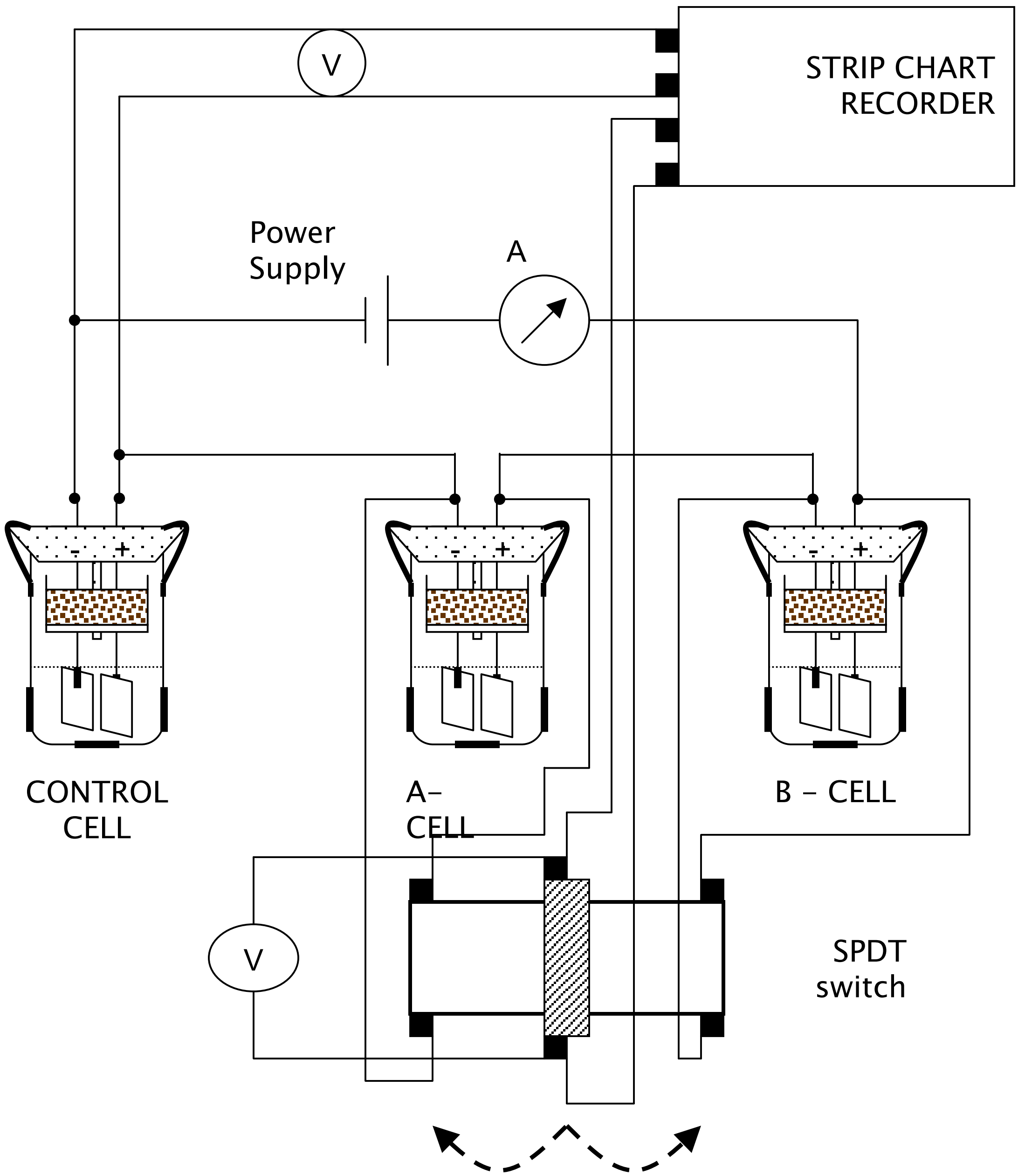


Figure: Circuit diagram. A Single-pole-double-switch (SPDT) switch was used to switch the voltmeter reading between the two experimental cells. ‘ ‘Represents a K-type thermocouple used for temperature measurement. All thermocouples were attached to a STP-36CJC-102-02A board manufactured by Kiethley. The board was connected to a computer which was used to read and paste temperature values in a MS Excel worksheet.

Equations for excess heat

At steady state:

Power IN = Power OUT – Anomalous power

$$IV_1 = k(T_1 - T_A) + \frac{dH_1}{dt}$$

$$IV_2 = k(T_2 - T_A) + \frac{dH_2}{dt} - \frac{dH_{xs}}{dt}$$

I = constant current

V_1 = control cell voltage

V_2 = experimental cell voltage

k = a constant

T_1 = control cell temperature

T_2 = experimental cell temperature

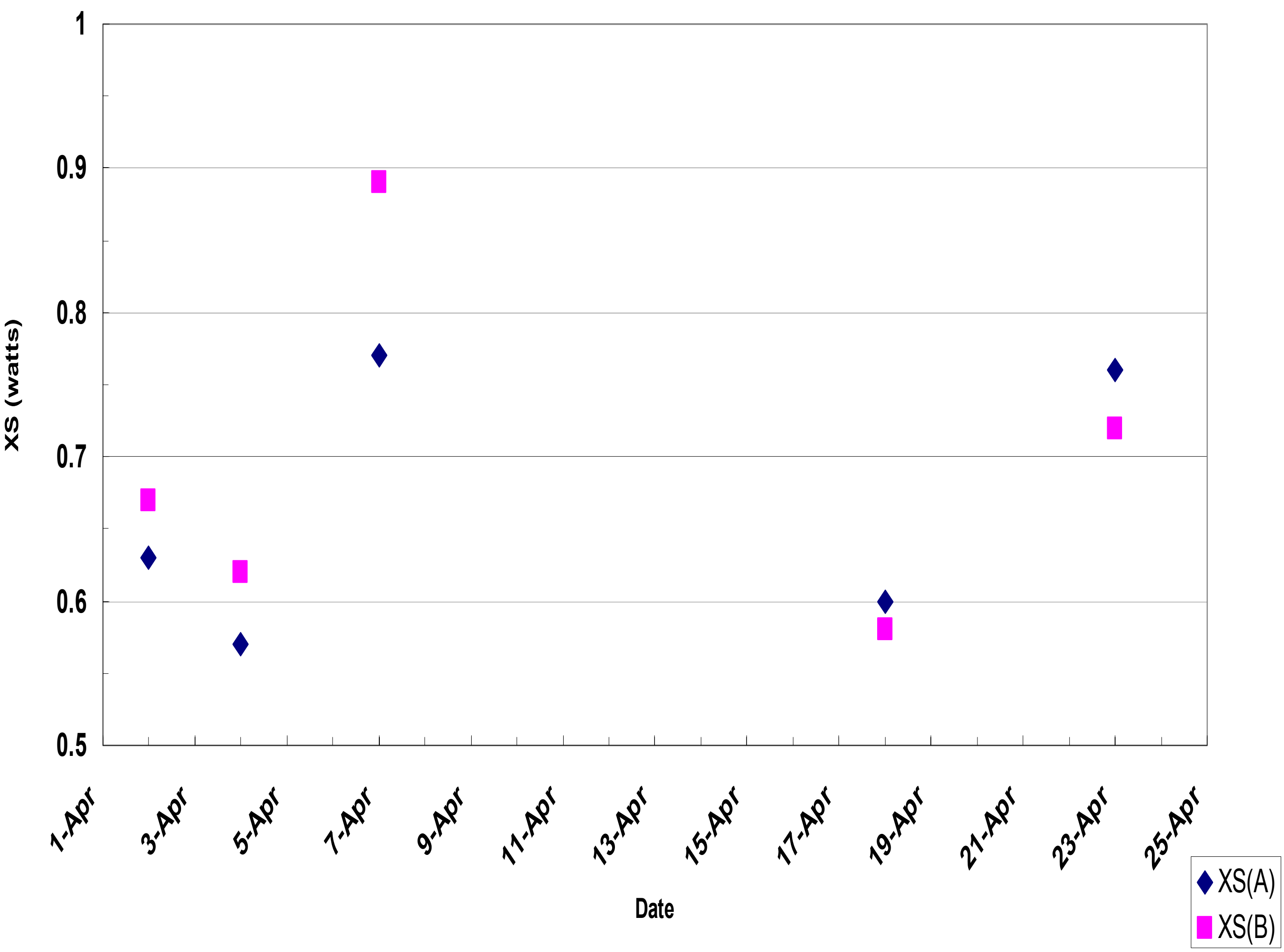
T_A = ambient temperature

dH_1/dt = power lost from control cell due to evaporation

dH_2/dt = power lost from experimental cell due to evaporation

dH_{XS}/dt = excess thermal power

Excess power data for 2 cells with Pd cathodes and heavy water electrolyte in comparison with a control cell which had a Pt cathode and light water electrolyte. Current = 3A,Current density = 0.48 A/cm-sq. Precision of measurement is estimated at +/- 0.1W



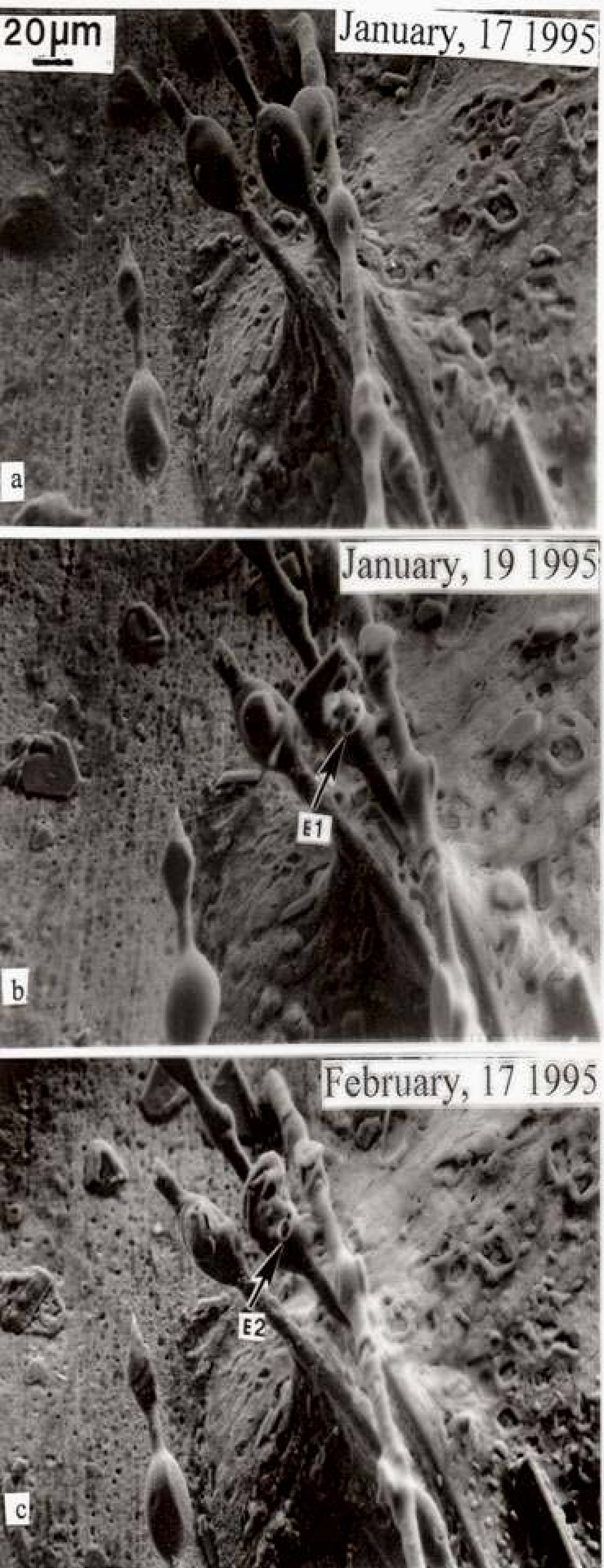
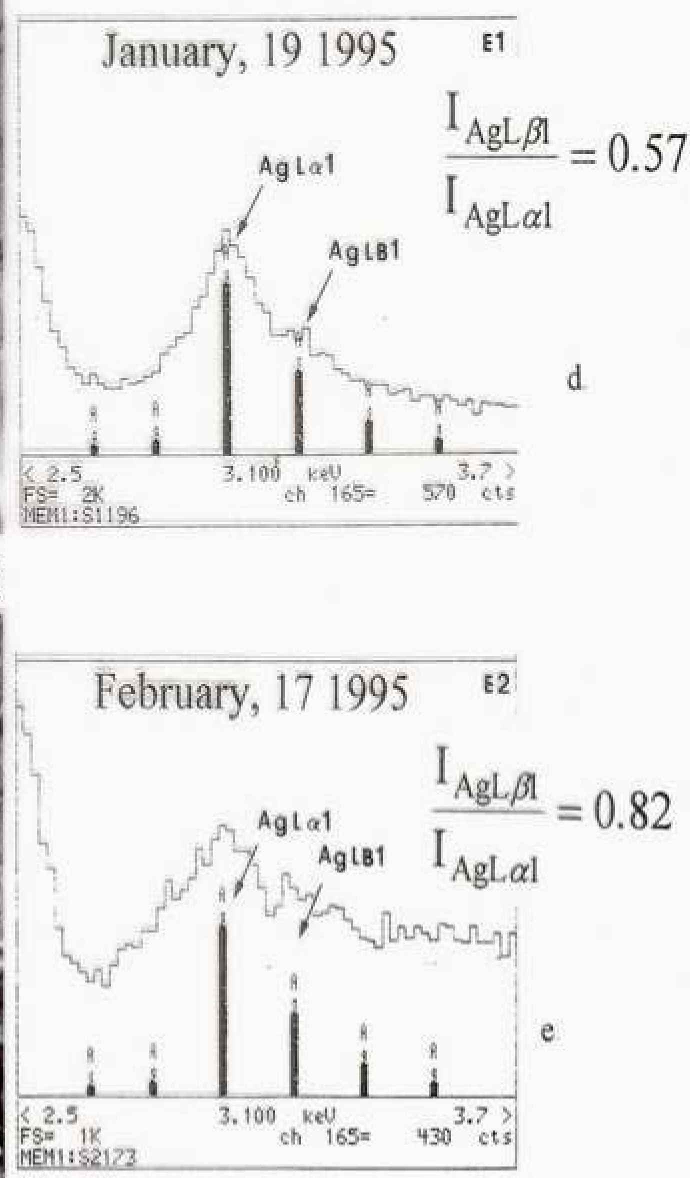
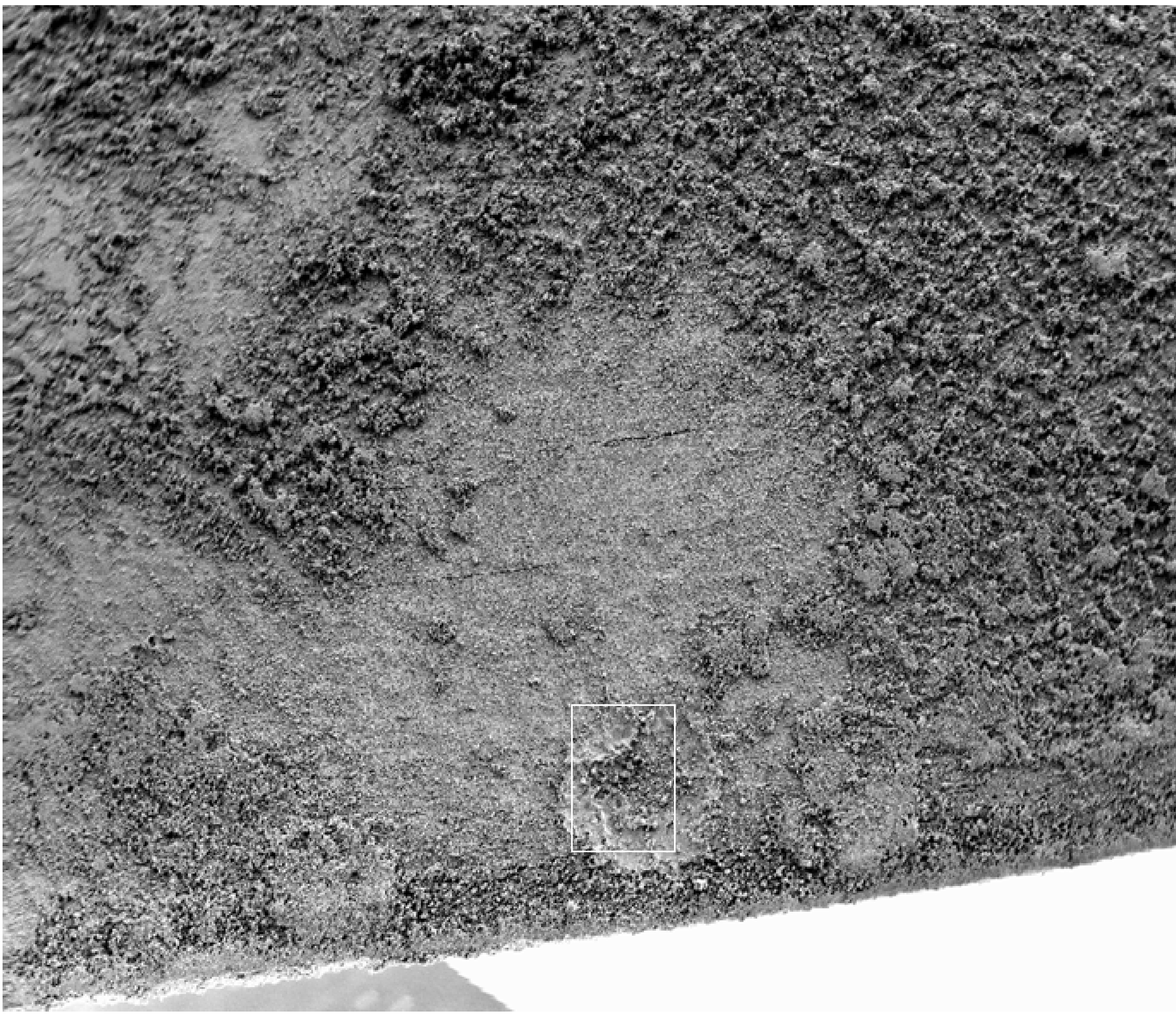
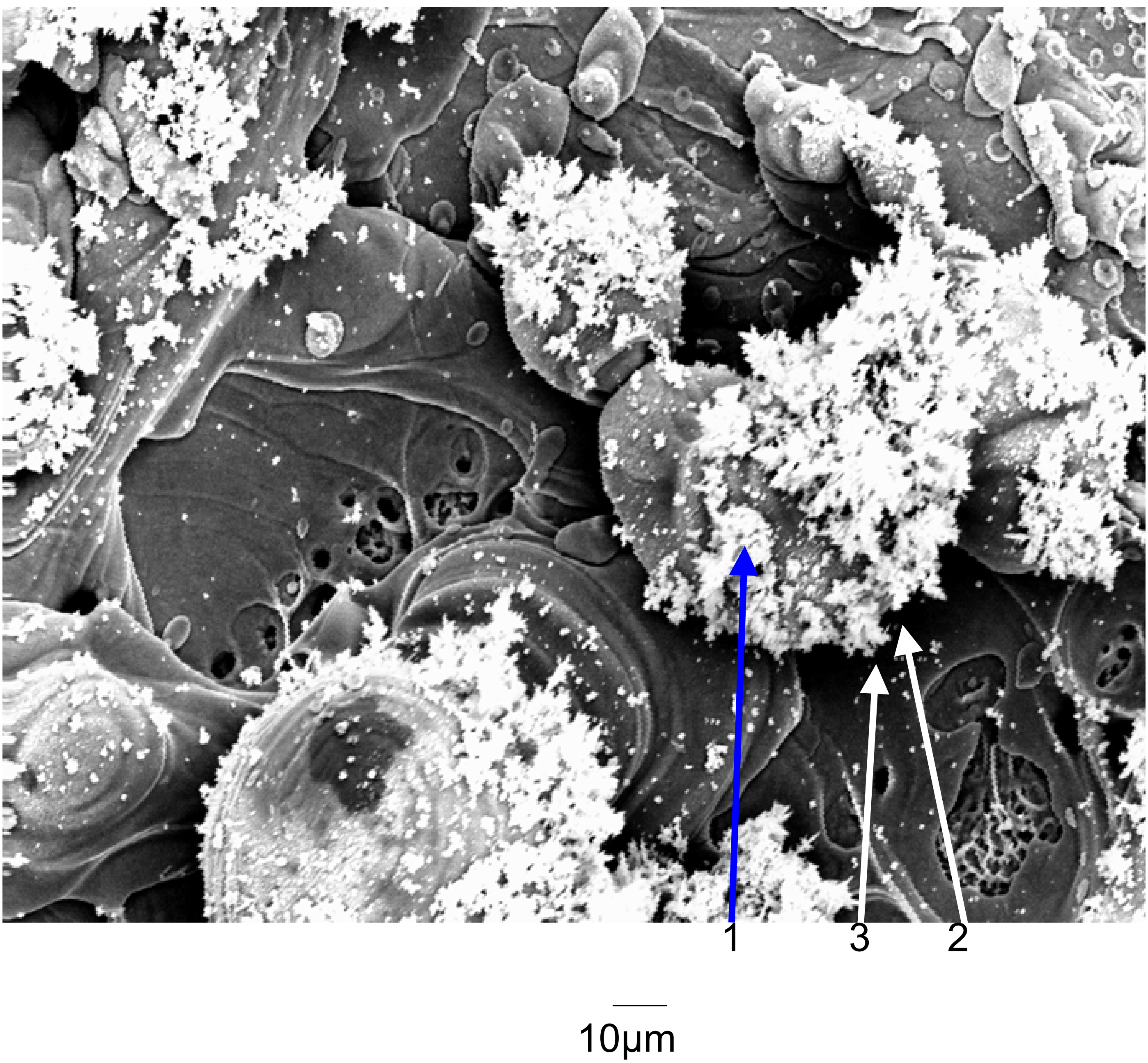


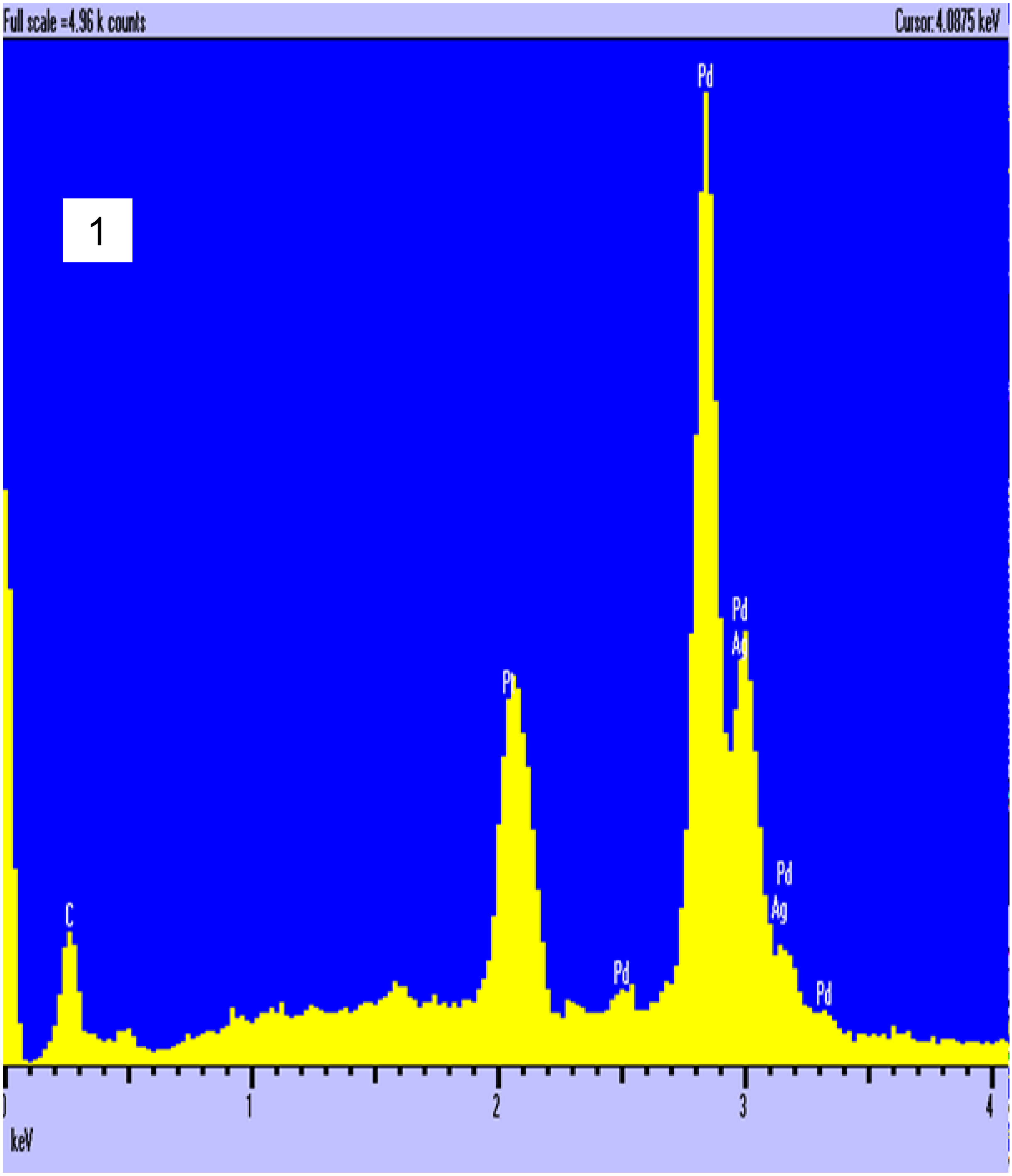
Fig. 5. Changes in morphology and EDS spectra of the features in the square shown in Fig. 4a. These changes occurred during storage at room temperature with no further electrolysis.



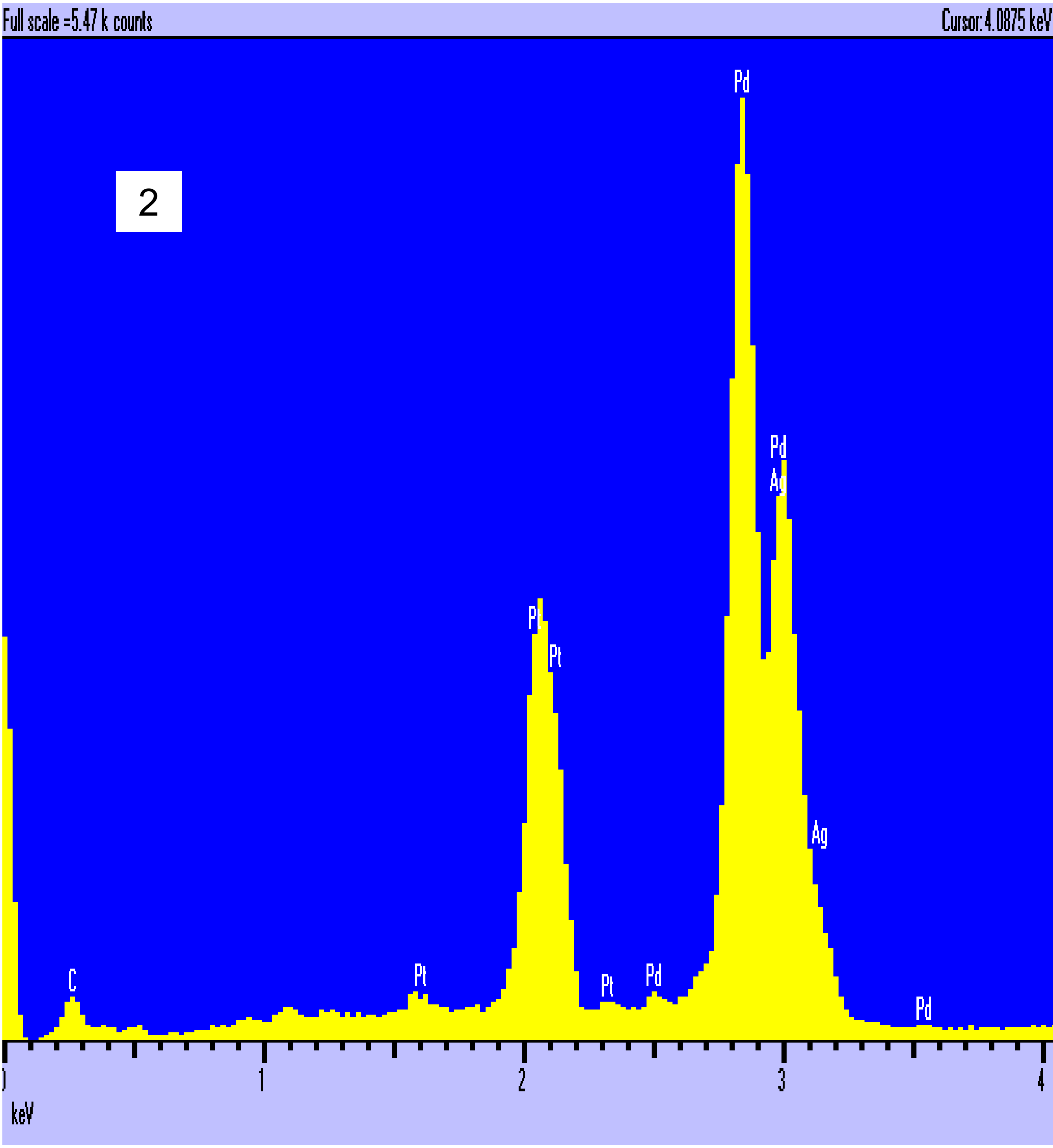


0.58mm

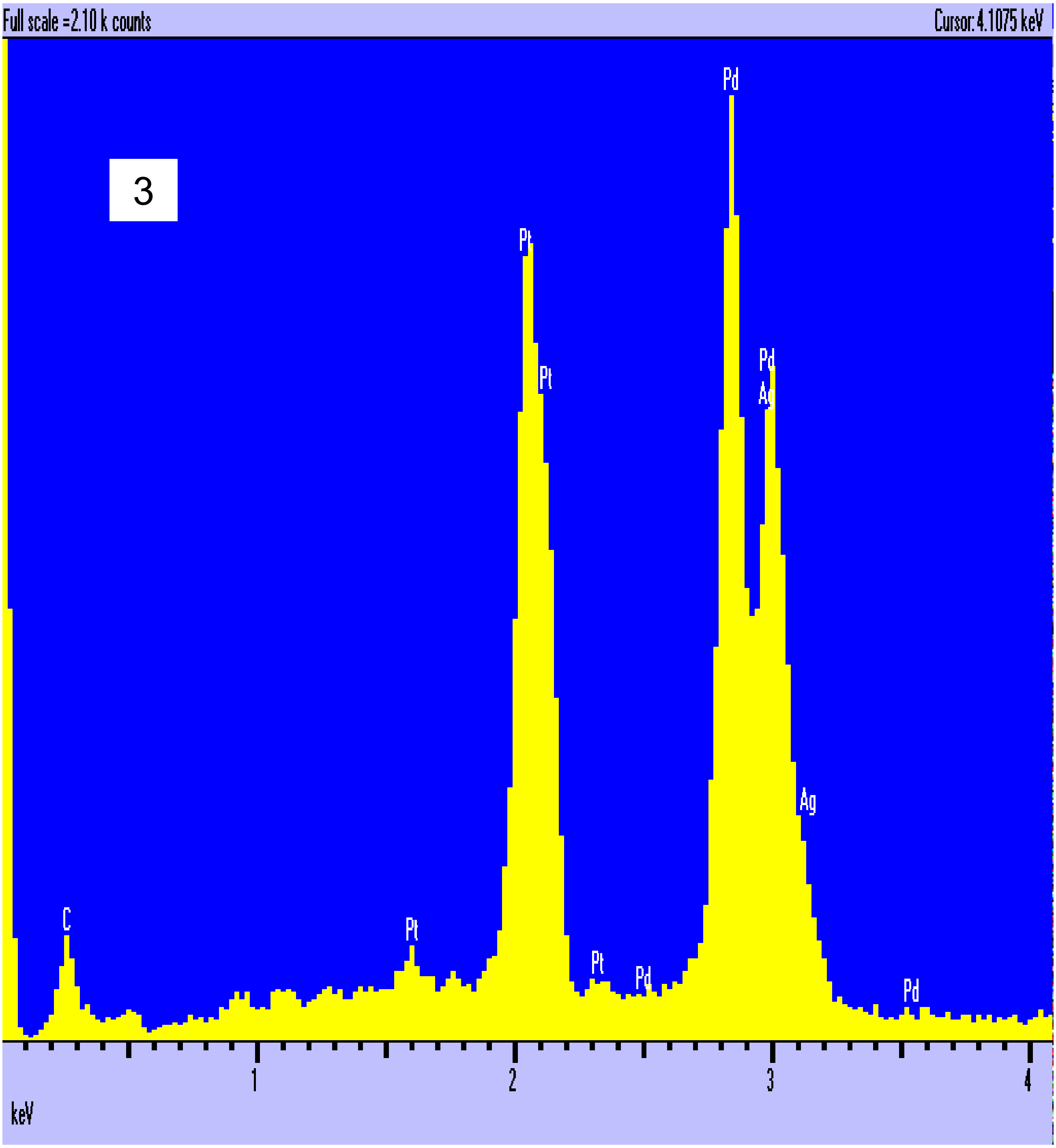

1
3
2
10µm



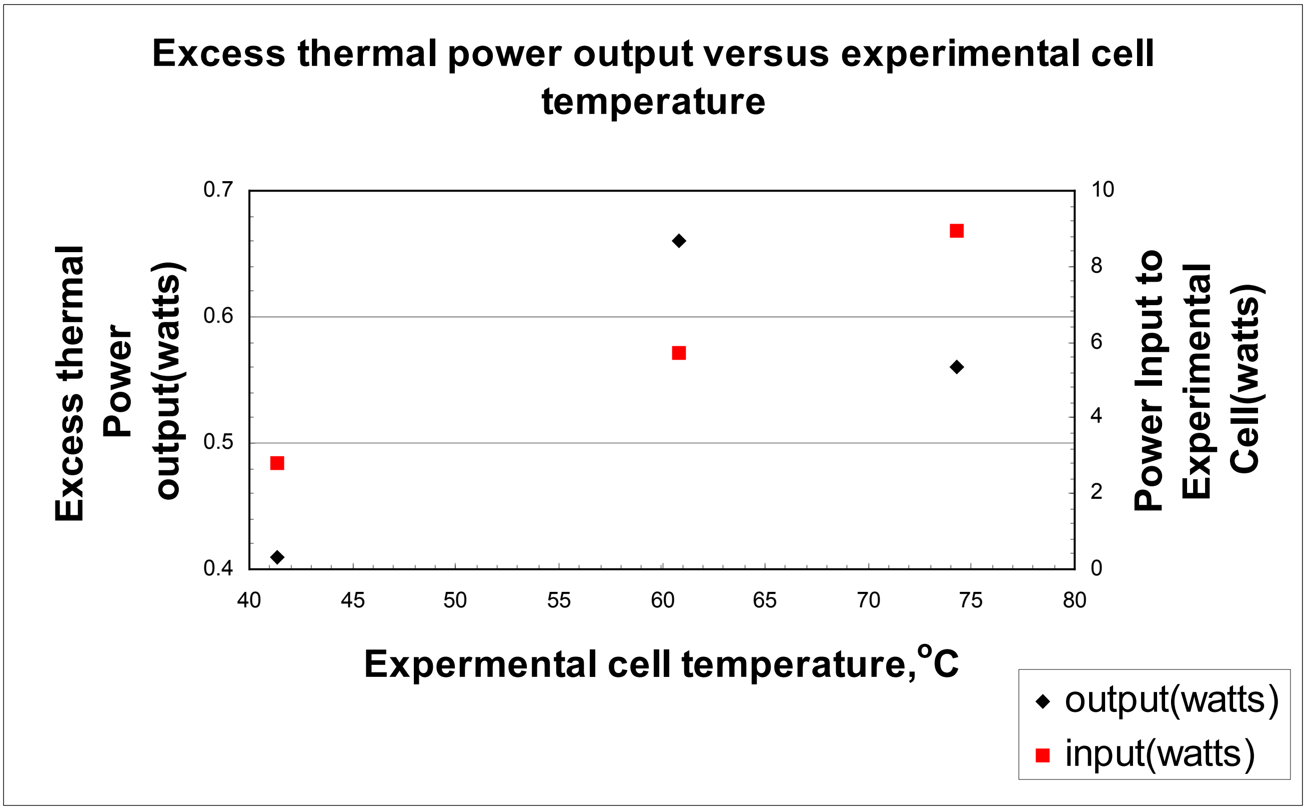
Palladium Lβ/Lα = 0.4 ➔ Elemental Silver = 0%



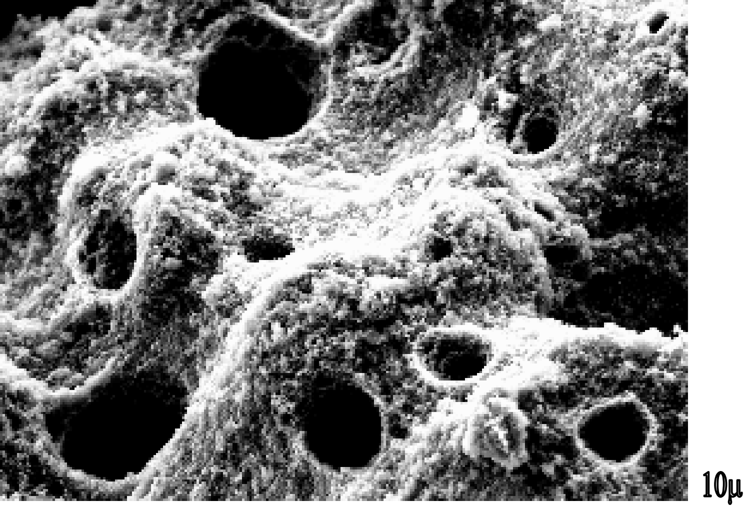
Palladium Lβ/Lα = 0.6 ➔ Elemental Silver = 7%



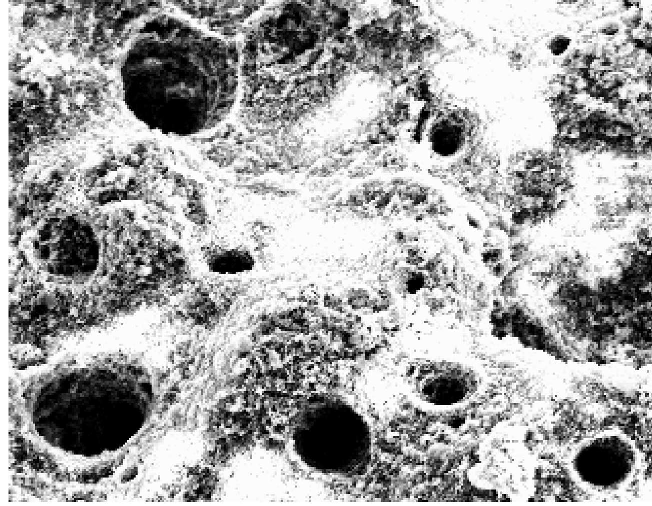
Palladium Lβ/Lα = 0.74 ➔ Elemental Silver = 10%



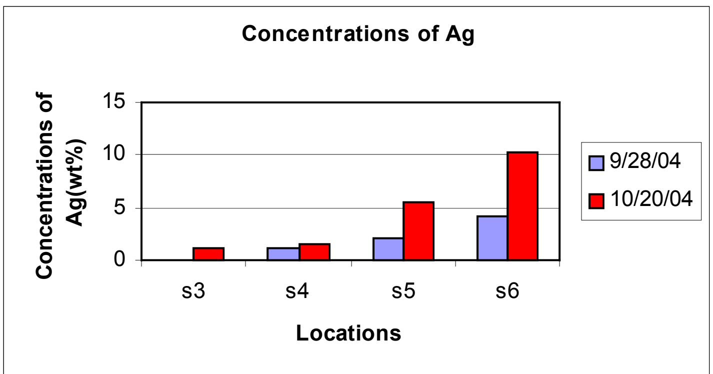
Excess thermal power output versus experimental cell temperature. Current density was about 0.5A/cm² for all three experiments. Pd cathode thickness was 0.05mm.

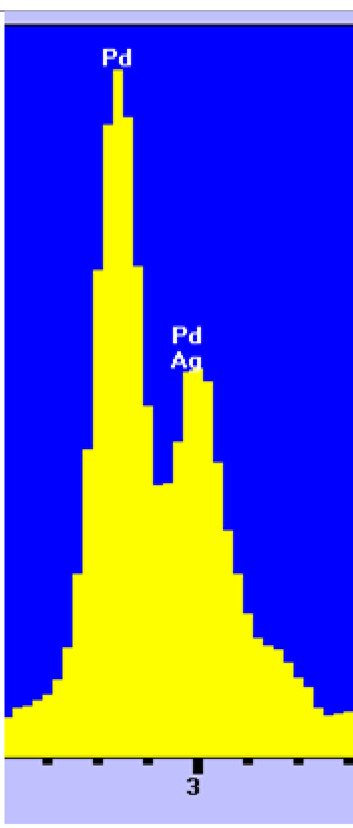


Pd-0.05mm-8mm-36mm—cv-0.15kx-Sep.28

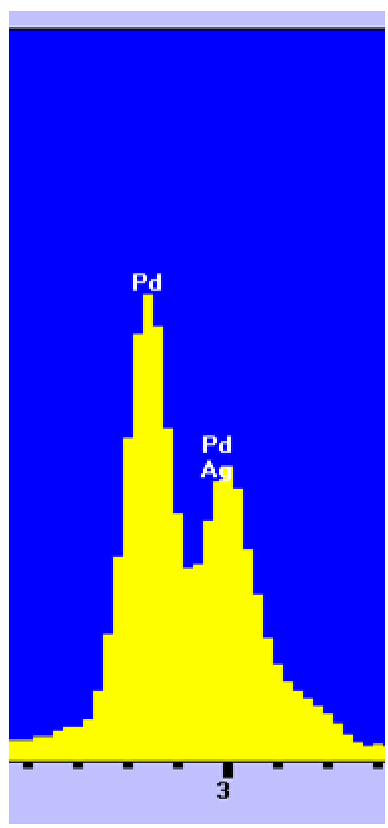


Pd-0.05mm-8mm-36mm—cv-0.15kx-Oct.20





Pd-0.05mm-8mm-36mm—cv-0.15kx, Sep.28-s6 (Pd Lb/La=0.57)

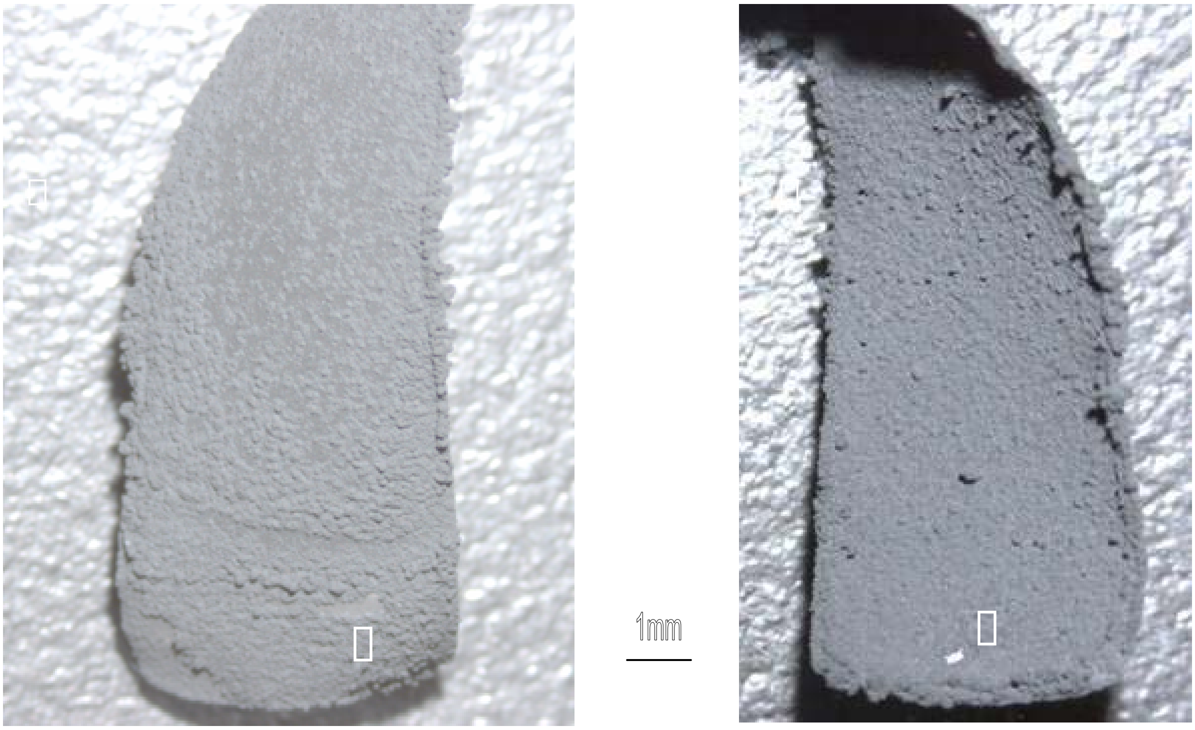


Pd-0.05mm-8mm-36mm—cv-0.15kx, Oct.20-s6 (Pd Lb/La=0.63)


1.0 mm
1.0 mm

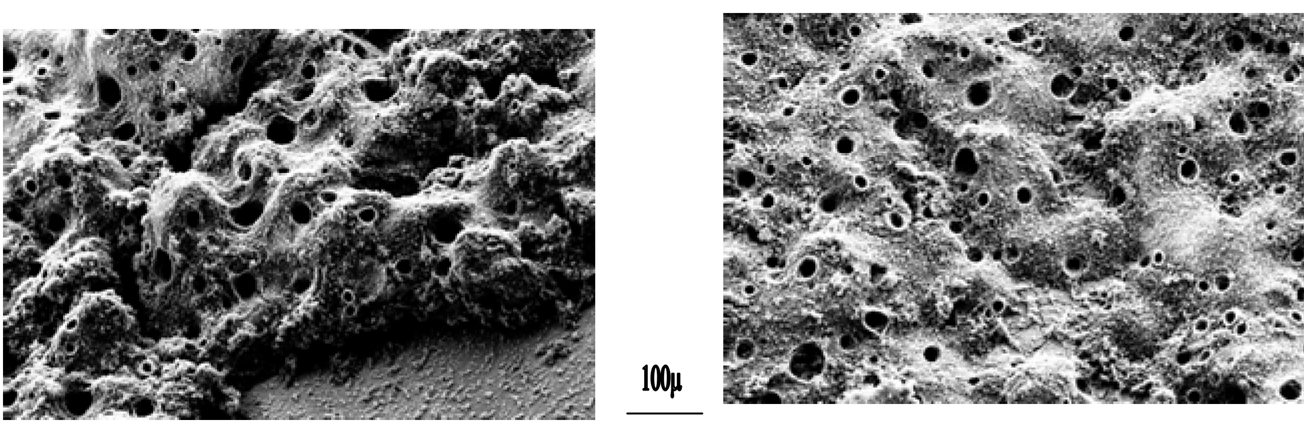
Pd-0.05mm-8mm-36mm Sample

1. Image



Pd-0.05mm-8mm-36mm-cv Pd-0.05mm-8mm-36mm-cc

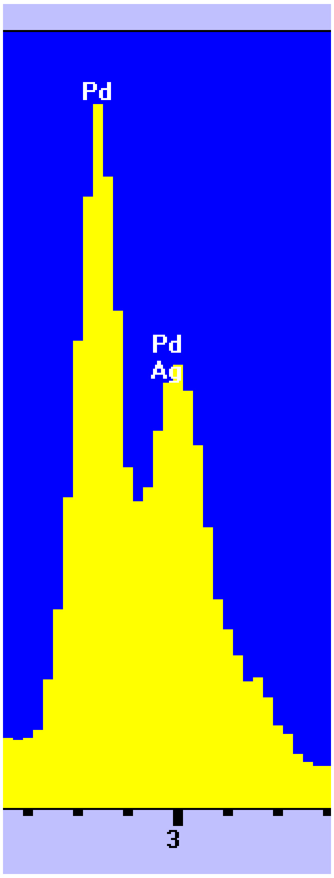
Fig.1.1 Image of sample Pd-0.05mm-8mm-36mm(small magnification)



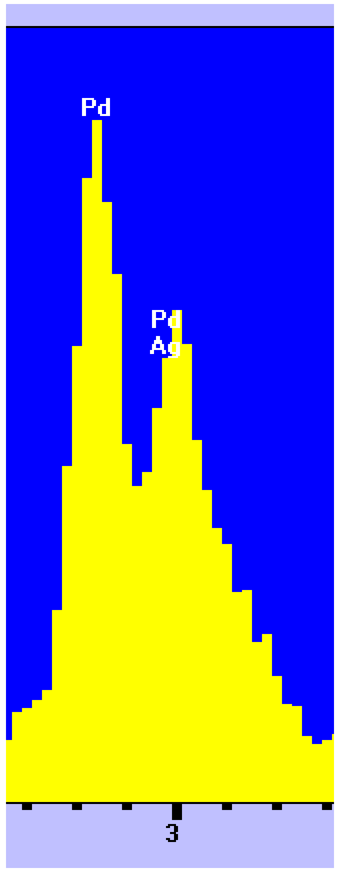
Pd-0.05mm-8mm-36mm-cv-0.15kx Pd-0.05mm-8mm-36mm-cc-0.15kx

Fig.1.2 Image of sample Pd-0.05mm-8mm-36mm (big magnification)

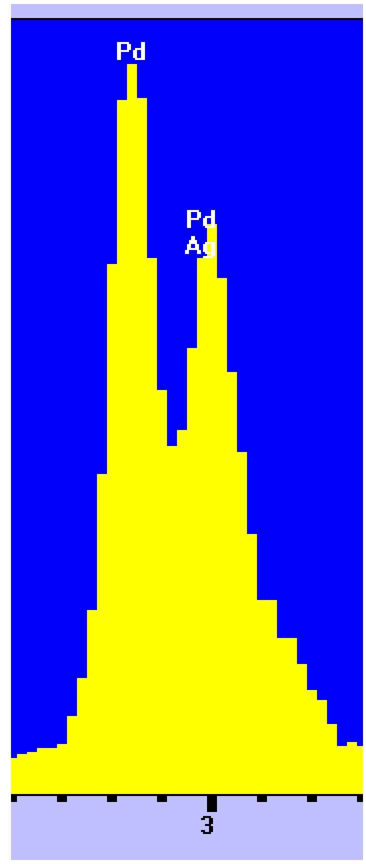
2. Spectrums



EDS of Pd-0.05mm-8mm-36mm convex, area s11, which has largest silver concentration, 4.02% (Pd Lb/La=0.63)



EDS of Pd-0.05mm-8mm-36mm convex, area s14, which has silver concentration, 1.9% (Pd Lb/La=0.73)



EDS of Pd-0.05mm-8mm-36mm concave, area s10, which has largest silver concentration, 9.56% (Pd Lb/La=0.78)

Figure: EDS of sample Pd-0.05mm-8mm-36mm

3. Concentrations

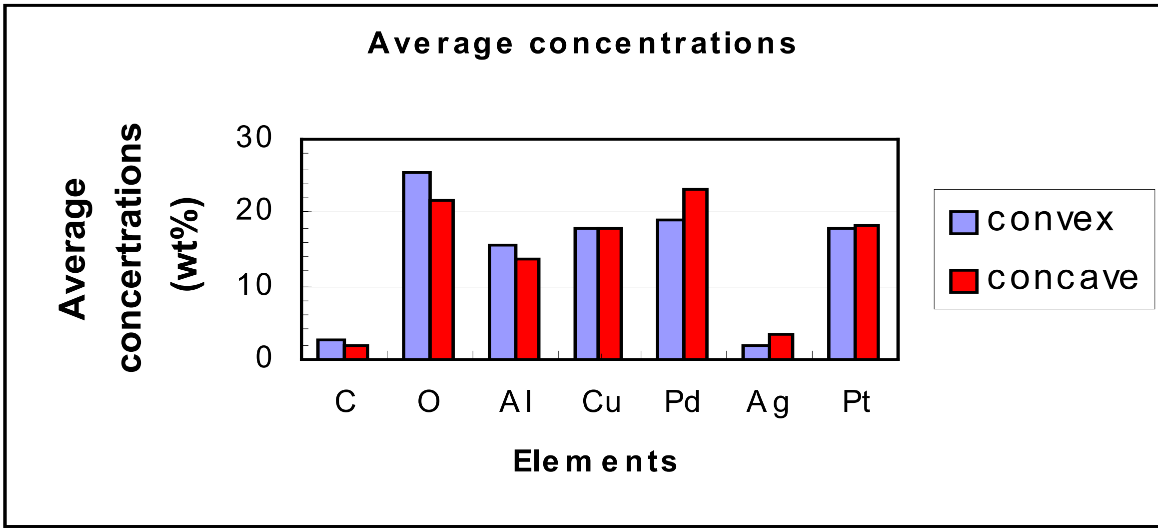


Figure: All concentrations of sample Pd-0.05mm-8mm-36mm

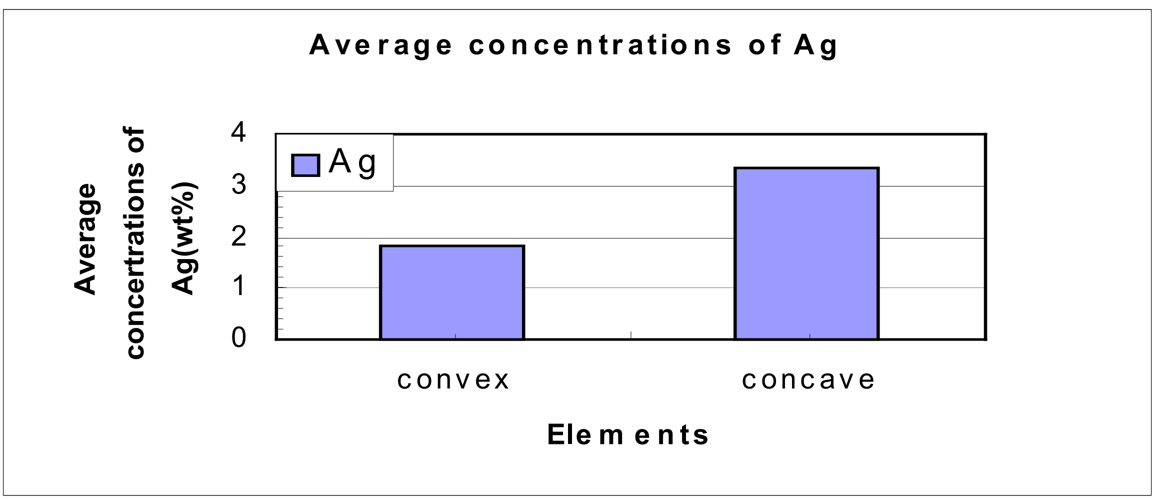


Figure: Ag concentrations of sample Pd-0.05mm-8mm-36mm

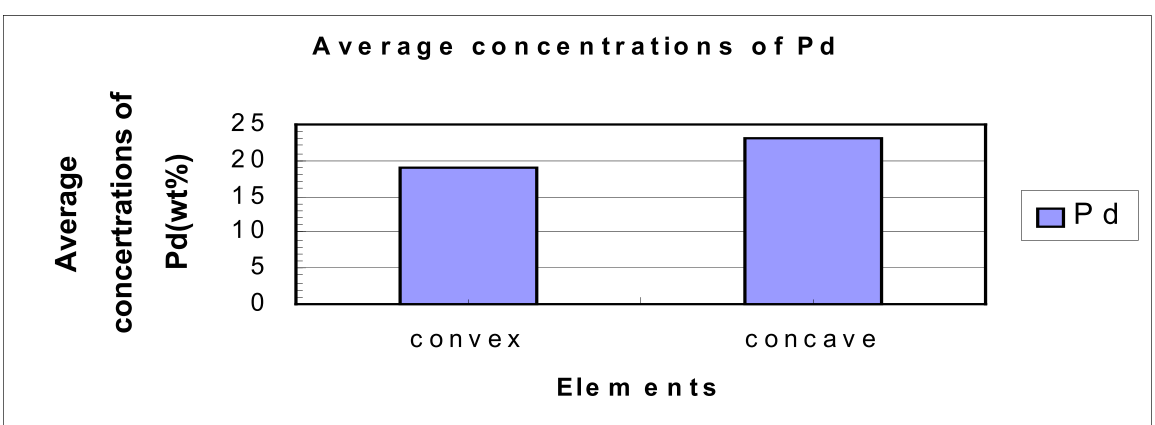


Figure: Pd concentrations of sample Pd-0.05mm-8mm-36mm