Calorimetry of Energy-Efficient Glow Discharges

Thomas B. Benson and

Thomas O. Passell

Advantages of Low-Power Glow Discharge Platform

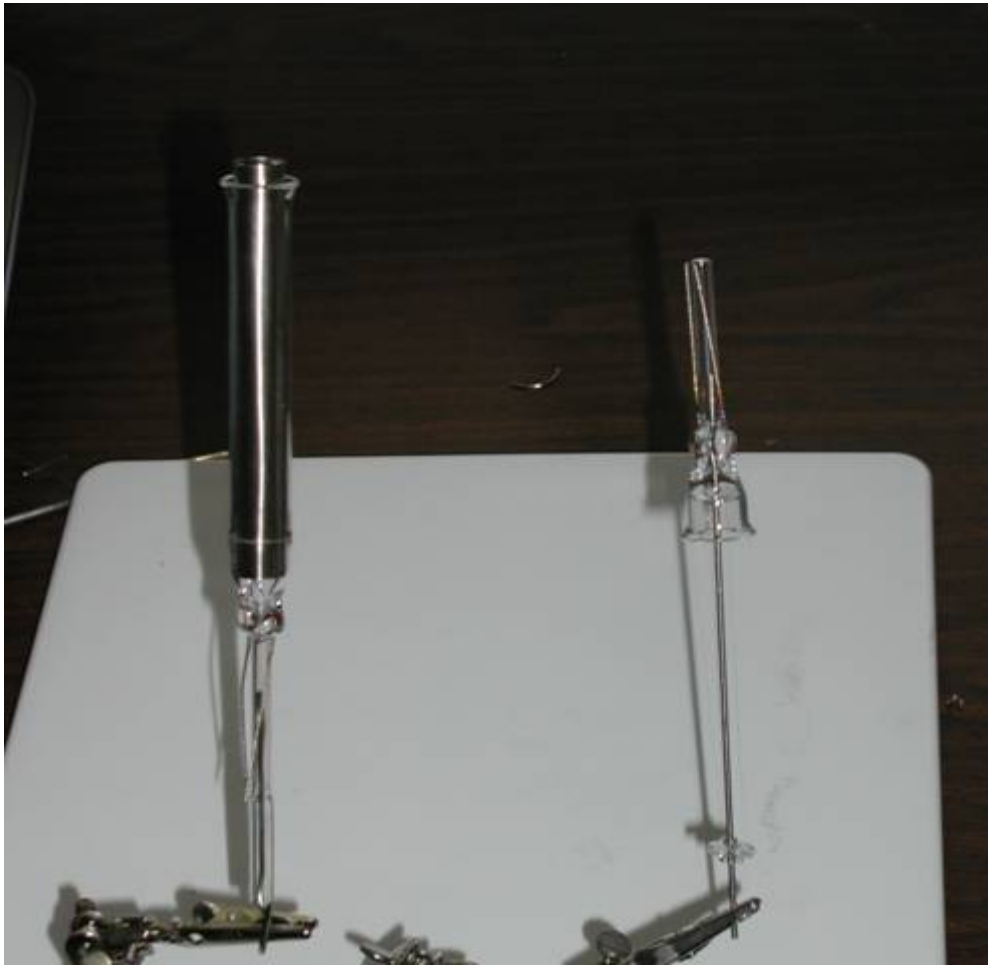
- Input power extremely low
- If triggered, effect should yield high signal to background ratio
- Accurate calorimetry is feasible (+- 10%)
- Allows in-situ sputtering with co-deposited nano materials and complex films
- Some good results reported (Dardik et al.)

APPROACH

- Large Number of Small Tubes in Multiple Geometries
- Use Low Power Excitation << few watts
- Calibrate with Resistance Heating
- Vary the composition of electrode surfaces with High Surface Area Metals-Pd, Ni, Ti, Ag, Au, & Pt
- Steadily Bleed gas mixtures of Argon, Hydrogen, Deuterium, and Helium to maintain constant pressure
- Monitor Temperature of Cells every ~5 Minutes with frequent calibrations on top of the discharge heat
- Sample Output Gas if Excess Heat Appears

Typical Glass Tube

(prior to final seal)

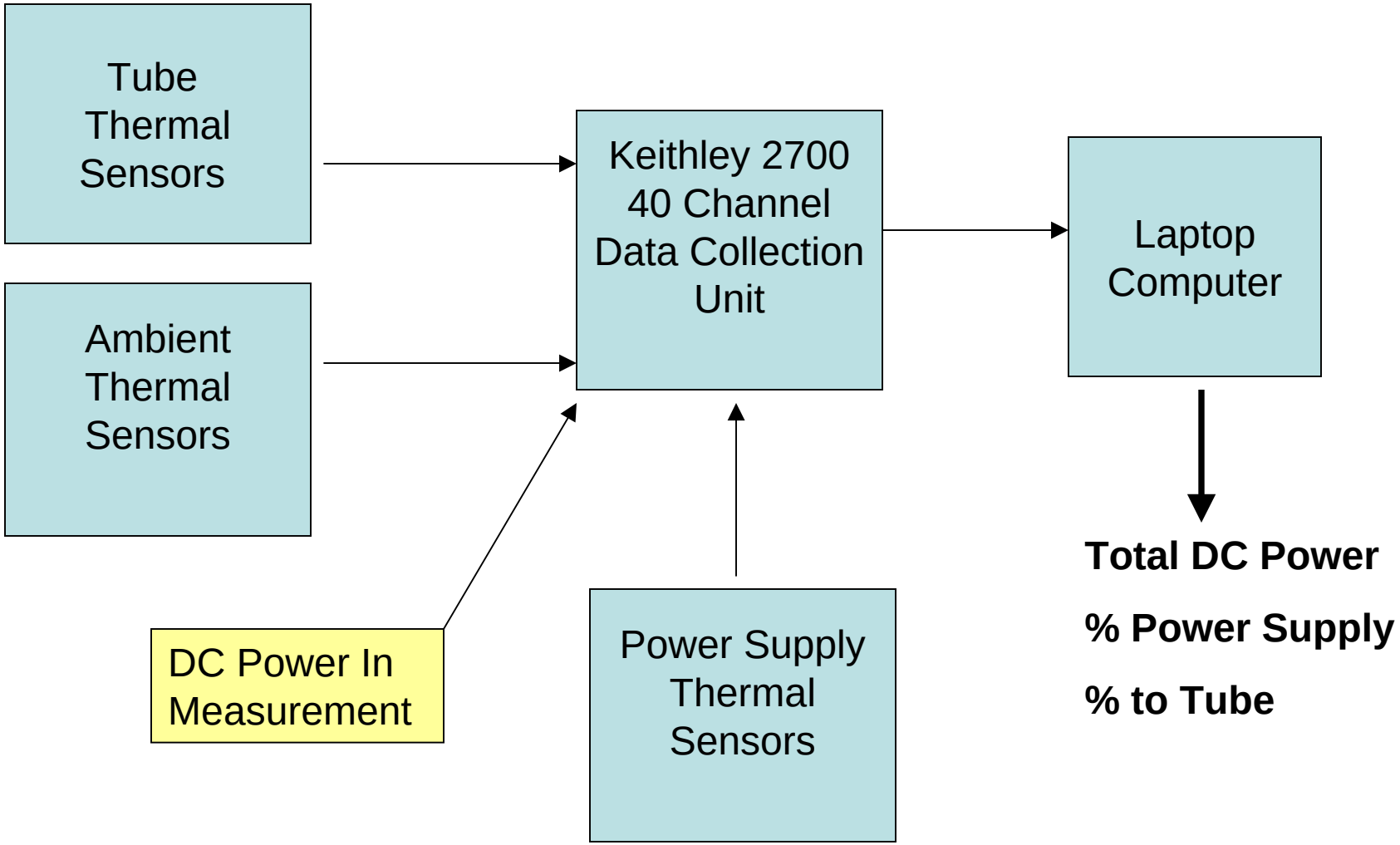


on vacuum rig

Calorimetry of Glow Discharge

- Glow at ~600 volts DC or AC
- Difficult to measure high voltage power to discharge
- Power absorbed at different efficiencies based on pressure, temp, gas composition
- So: we electrically measure DC input to high voltage power converter
- Power converter is miniaturized in separate calorimeter

Electronic Data Collection and Analysis

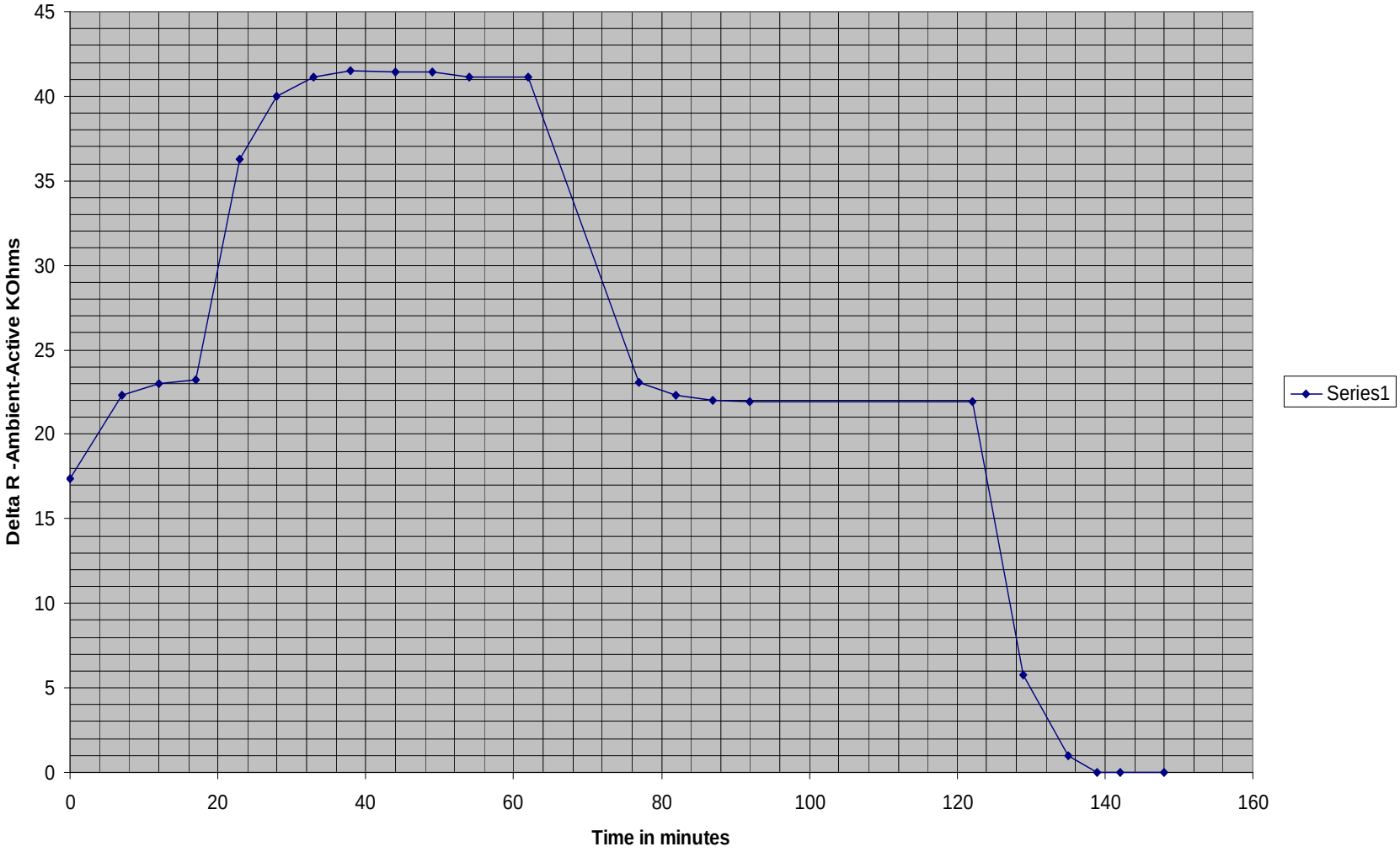


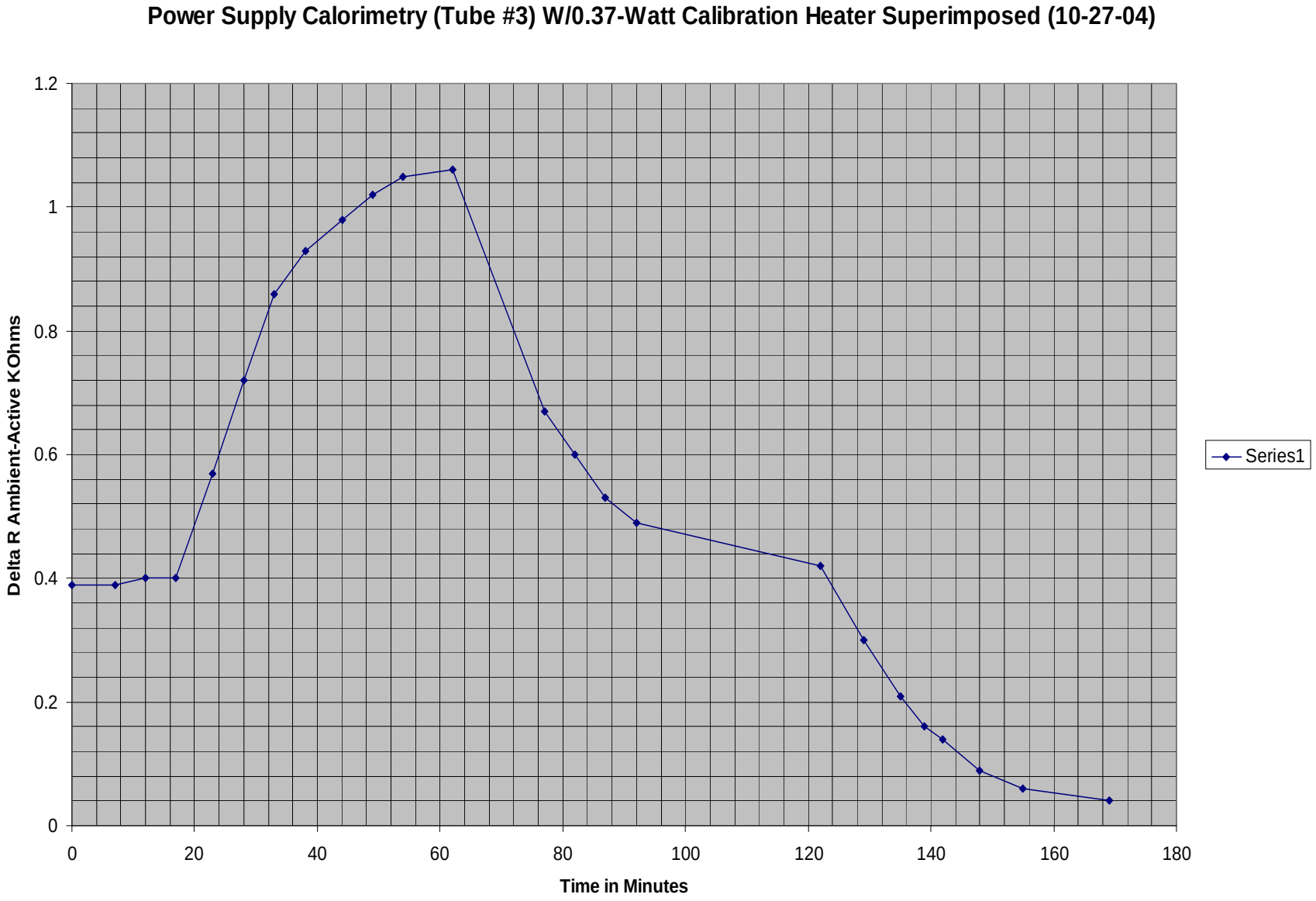
Power Balance Varies Based on Power Applied

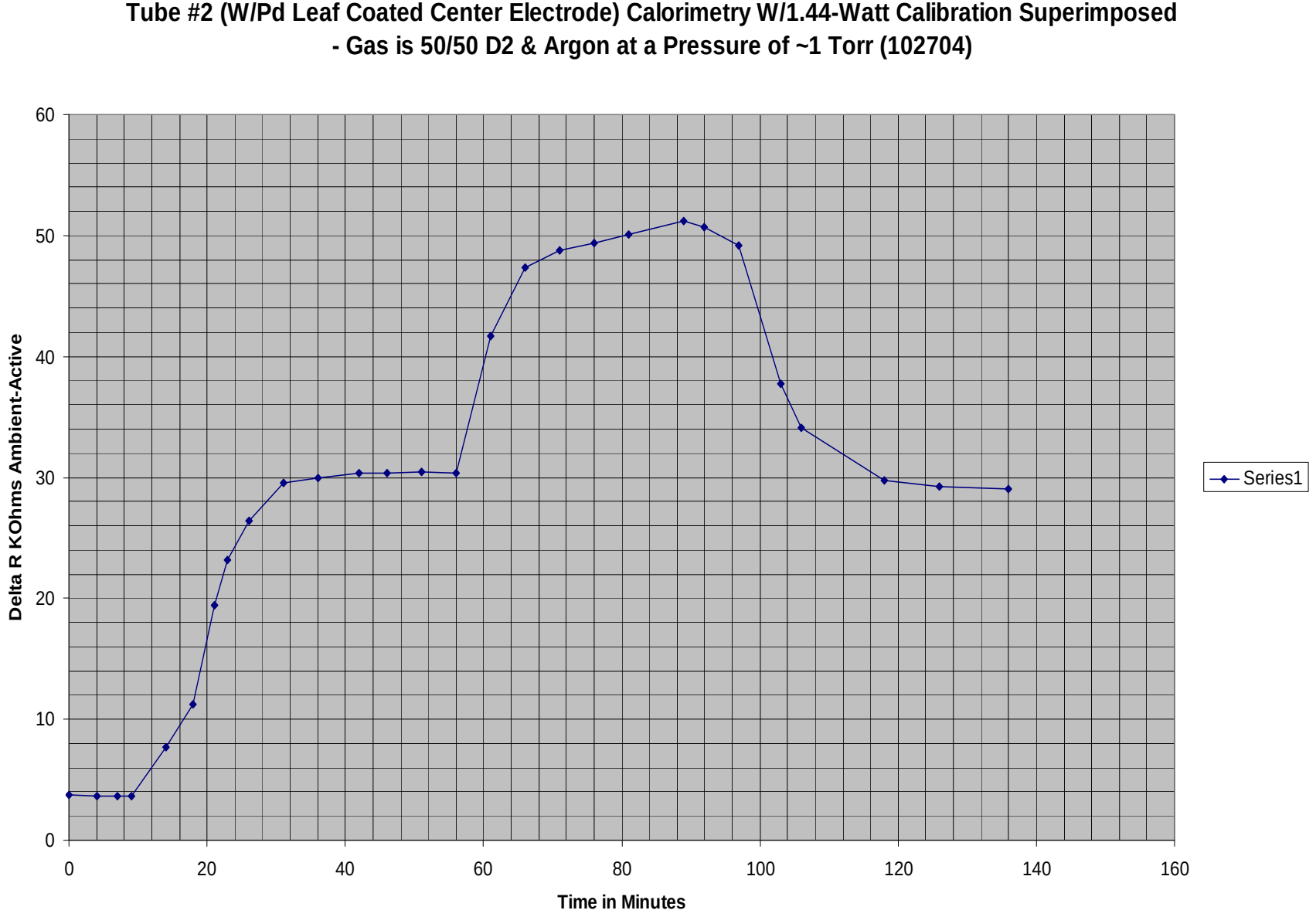
Typical results for single control tube, variable power input

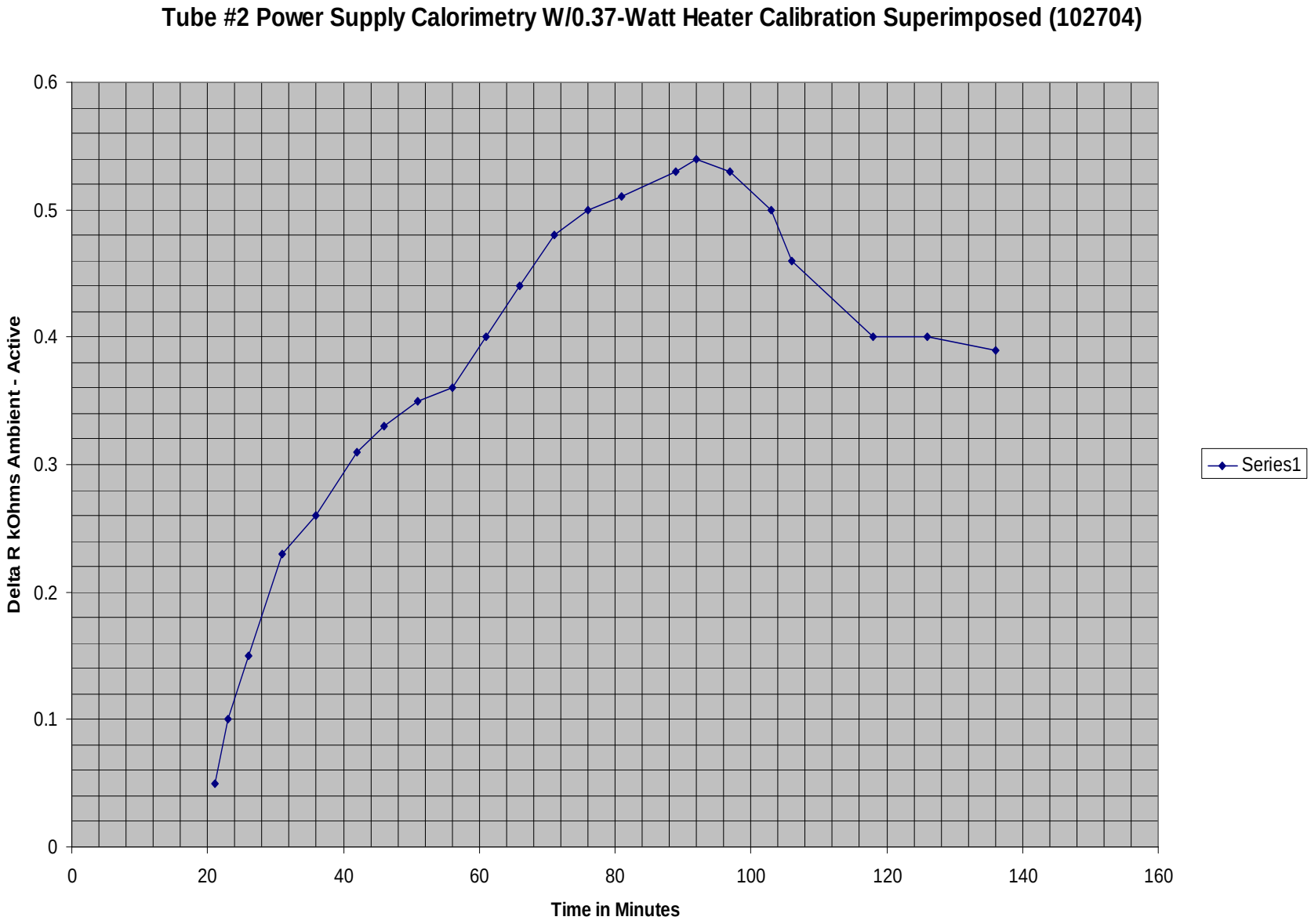
Power in	Calcuated from Calorimeter					
DC Watts	Power Supply		Tube		Total	% Power In
0.1378	0.1246	90.39%	0.0138	10.00%	0.14	100.39%
0.988	0.5854	59.25%	0.4142	41.92%	1.00	101.17%

Tube #3 Bare Zn-Coated Steel Center Electrode w/1.44 Watt Calibration Superimposed
Gas 50/50 D2 + A at ~1 Torr (10-27-04)




Power Supply Calorimetry (Tube #3) W/0.37-Watt Calibration Heater Superimposed (10-27-04)
Delta R Ambient-Active KOhms
1.2
1
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
120
140
160
180
Time in Minutes
Series1


Tube #2 (W/Pd Leaf Coated Center Electrode) Calorimetry W/1.44-Watt Calibration Superimposed
- Gas is 50/50 D2 & Argon at a Pressure of ~1 Torr (102704)
Delta R KOhms Ambient-Active
60
50
40
30
20
10
0
0
20
40
60
80
100
120
140
160
Time in Minutes
Series1


Tube #2 Power Supply Calorimetry W/0.37-Watt Heater Calibration Superimposed (102704)
Delta R kOhms Ambient - Active
0.6
0.5
0.4
0.3
0.2
0.1
0
0
20
40
60
80
100
120
140
160
Time in Minutes
Series1

Tentative Conclusions

- Reliable Glow Discharges Have Been Obtained in Brass Pipe Crosses of 9 mm Inside Diameter W/Various Center Electrodes of ~3 mm Diameter Threaded Rods @ Gas Pressures of 1 Torr (50/50 D2 & Argon)
- Initial Data Show Excess Heats (XSH) of 43% Above Input 40 Khz AC for Zn-Coated Fe-(An Intended Blank)
- Coating the Zn/Fe W/Pd Leaf Increased the XSH to 75%
- In Both Cases the Uncoated Brass Served as the Irregular Cylindrical Electrode
- Calorimetry Established the DC-to-40 Khz Power Supply was 47% Efficient in the Conversion of DC to AC

Next Steps

- Expand to full-scale process
- Incorporate Ag, Au, Pt, Pd, Co, V nano-particles in Palladium or Platinum sputtered matrix
- D/He, D/Ar, H/He, H/Ar gas mixes

Approach 2: Sealed Glass Glow Discharge Tubes

- Advantages include Independence from Vacuum and Gas Charging System, Simplification of Calorimetry, and containment of Possible Reaction Products
- Disadvantages include loss of control of gas pressure which can vary if Gas adsorption or emission occurs from electrode metals and Loss of ability to find the optimum gas pressure and Mixture composition