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Cathode Fabrication Methods to Reproduce the Letts-Cravens Effect

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A method is disclosed to fabricate a Palladium cathode that can be electrolyzed in heavy water and stimulated with a laser at a predetermined wavelength to produce apparent excess power; the fabrication method involves cold working, polishing, etching and annealing the Palladium prior to electrolytic loading with Deuterium. Loading is accomplished with the cathode sitting in a magnetic field of 350 Gauss. After loading the cathode with Deuterium, Gold is co-deposited electrolytically on the cathode. When a coating of Gold is visible on the cathode, co-deposition is halted and the cathode is stimulated with a low-power laser with a maximum power of 30 milliwatts. The thermal response of the cathode is typically 500 mW with maximum output observed of approximately 1 watt. The effect is repeatable when protocols are followed and has been demonstrated in several laboratories.

Introduction

By trial and error we have developed a method of cathode fabrication that creates a cathode capable of being stimulated by laser light so as to produce thermal energy in excess of that provided by the laser. The ratio of laser power to the excess power observed experimentally is typically 10 or 20 to one. This effect has been observed by others and may lead us to a better understanding of the physics behind what has been called cold fusion.

Step 1 Cut a billet of Palladium

Step 1 is simply to cut a billet of Palladium; we typically use 0.999 Pd from Alfa Aesar but have had results from different Palladium sources and purity. The billet is typically 10 mm x 8 mm x .5 mm.

Step 2 Polish the Cathode

Step 2 is to polish the cathode using a Dremel tool equipped with a metal brush and a fiber brush. We have been using a product called Nicksand as a polishing compound. Nicksand can be found on the internet and is an Aluminum Oxide paste that provides a very fine finish.

The compound is best applied using a toothbrush and tap water, keeping the slurry thin. The metal brush is used first to roughen the surface. The fiber brush is then used to restore the surface to a bright finish. The slurry will change from white to grey to black. Black slurry indicates that the piece is highly polished. Rinse with tap water to confirm that the surface is bright.

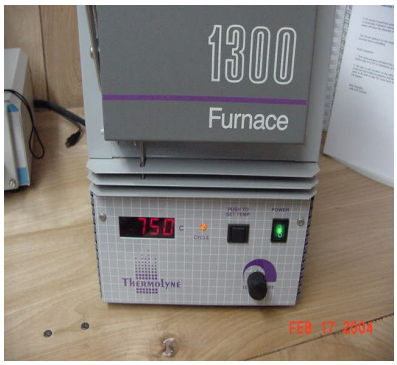
The Slurry

As mentioned above, the slurry color change is visible in this slide; water can be added to thin the slurry which makes it easier to bring the piece to a bright finish.

Step 3 Rinse work in tap water

Rinse work in tap water; after polishing the Palladium for several minutes with the fiber brush, the surface will become very bright and smooth.

Step 4 - Heat in furnace at 750 °C

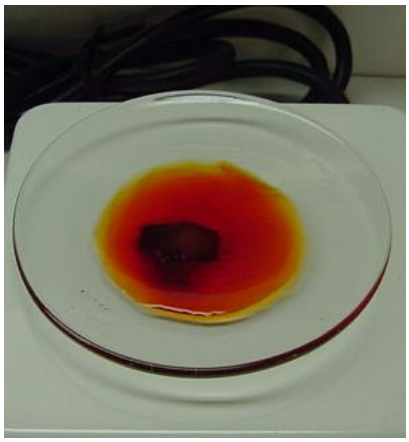


Place the work in a lab furnace for 3 hours at 750 °C; this step is to clean the surface by bringing the piece to red heat for an extended period.

The Oxide Layer

By cooling the Pd slowly, an oxide layer is formed on the metal; the layer will appear blue. The oxide layer will be removed in subsequent steps.

Step 5 – Acid Etch



The oxide layer is partially removed with a 2 minute etch in Aqua Regia, usually at room temperature. Sometimes we etch on a hot plate, using a maximum temperature of about 100 °C.

Step 6 – Re-polish the cathode

Repeat the polishing step, beginning with the metal brush and following up with the fiber brush. Keep the slurry thin.

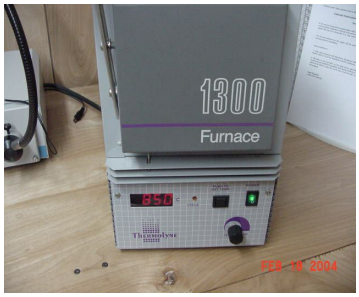
Step 7 – Polish to bright

When the slurry darkens, check the surface for brightness—it should be about right after several minutes of polishing with the fiber brush.

Step 8 – Ultrasonically clean for 5 minutes

We normally use distilled water without cleaner at this stage.

Step 9 – Anneal at 850 °C



Heating the work to 850 °C changes the crystal structure-the grain size increases; this may be important.

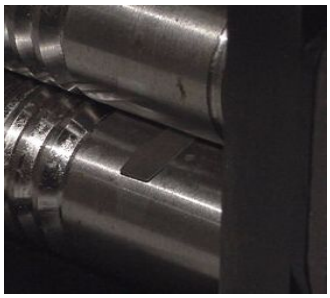
Step 10 – Re-Polish

When the work is polished to bright, the Pd is ready to clean thoroughly and cold-roll.

Step 11- Ultrasonically clean prior to cold-rolling

Before cold-rolling, it's important to get the surface clean; for this step we use distilled water with either oxide or compound remover.

Step 12 – Cold roll



We use an inexpensive cold-roller to reduce the Palladium thickness by about 50%; typically we roll the piece from .5mm thickness to about .25mm. We make the roll in four passes-one in each direction to avoid having a preferential stress direction.

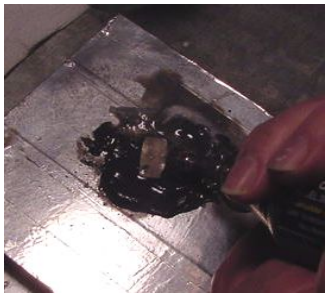
Check the thickness

We try to finish the cold roll with a thickness of about 0.25mm because the final etch will reduce the thickness by about 0.05mm. Cathodes less than 0.20 mm thick tend to curl from the stresses of loading.

Cathode Enlargement

After cold-rolling, the work is large enough for several cathodes; the surface needs to be re-cleaned.

The Final Polish



Using the metal brush, the surface is again buffed then polished to a mirror finish using the fiber brush.

Step 13 – Polish to Bright

The cathode material is now ready for an ultrasonic cleaning and final annealing.

Step 14 – Ultrasonically Clean

Clean for 5 minutes in distilled water and a compound remover.

Step 15 – Final Anneal at 850 °C

The work is annealed for the last time at 850 °C that further increases the grain size and relaxes the stresses induced from cold-rolling.

Step 16 – Acid Etch

The entire piece is etched in Aqua Regia for 2 minutes at room temperature OR at elevated temperature if the oxide layer is difficult to remove. Maximum temperature we use is about 100 °C.

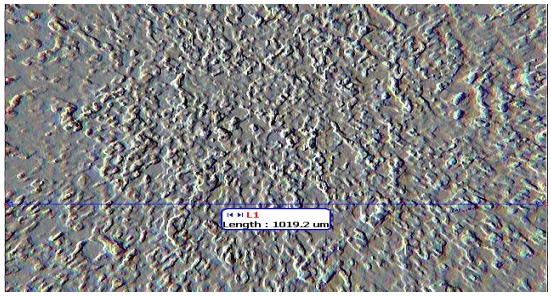
Step 17 – Clean after etching

Ultrasonically clean again for 5 minutes after etching; we normally use compound remover for this step.

The finished surface

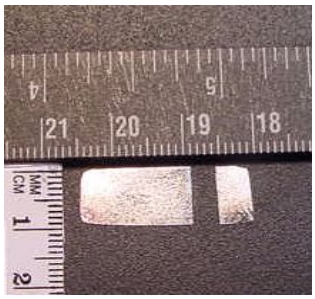
After etching, the surface is bright but has a matte-finish and the surface area has been increased.

The cathodic surface in relief view



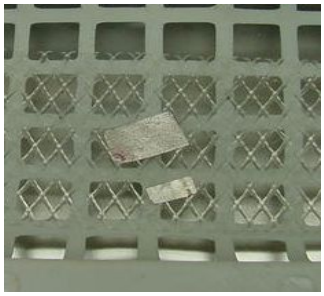
The digital microscope camera we use can render an image showing the relief structure of the surface. This is a typical result. The width of the entire field is 1,019 microns. Having a final cathode surface that looks like this under the microscope appears to be important. If the surface is smooth, the laser effect is not observed.

Trim work and cut cathode



We normally make our cathodes about 5mm wide and 10mm long, 0.20mm thick.

Clean in distilled water



You can’t be too clean—we usually clean both pieces again for about 5 minutes.

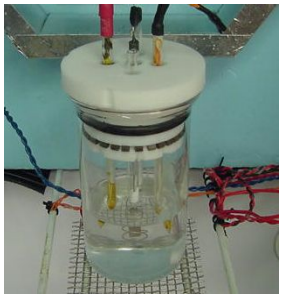
Spot weld cathode

We normally spot weld the cathode to 0.5mm Pt hook-up wire. The Pt wire is then placed in a 5mm glass tube, epoxied on the top end and the immersed end is filled with Teflon tape to support the wire.

The anode-cathode assembly

We use a Teflon lid with 5 pass-thru's with the cathode in the center hole and the anode support tube is behind the cathode support tube. To the left are the epoxied ends of the glass tubing and to the right are the Teflon-taped ends. The Pt anode surrounds the cathode with a diameter of 10mm and at least 3 turns over the cathode.

Fill the cell with LIOD



We typically use 75 g of 1M LIOD for the electrolyte in a closed cell; recombination is accomplished by using Platinum catalyst pellets from Alfa-Aesar. The pellets are very inexpensive yet effective. The pellets need to be cleaned before first use.

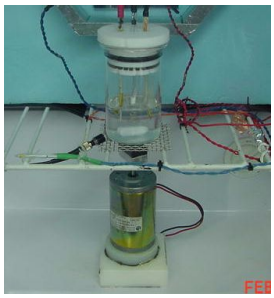
We clean the pellets in three passes using white vinegar, then rinse in distilled water and a final rinse in Methanol. The pellets are dried in a ceramic bowl using a heat gun. The pellets work best when the cell temperature is above 40 °C.

Ambient temperature control

Our experiments are typically conducted in an Avanti wine cooler designed by Scott Little and equipped with multiple fans and a resistance heater to balance against the cooling compressor.

Our data acquisition system is Labview based and controls the box temperature using proportional methods. Our typical box temperature is 25c +/- 0.02 °C.

Stirring option



We usually run with magnets around the cell, which precludes stirring magnetically; we are, however, able to stir when required.

Although most of the time we don't stir the cell, we do provide tight ambient temperature control and keep power to the cell constant to within about 20 mw. We also use two thermistor probes, which should stand up to most objections to excess power claims.

Loading the cathode

We load our bulk cathodes at a constant current of .1 amps for 120 hours; after loading cell current is raised to 1.5 amps for 24 hours. Then Gold is plated electrolytically in intervals of 10 minutes and tested for laser effect. If protocols are followed, the following photos show typical results over the past 3 years.

#512e – September 2000

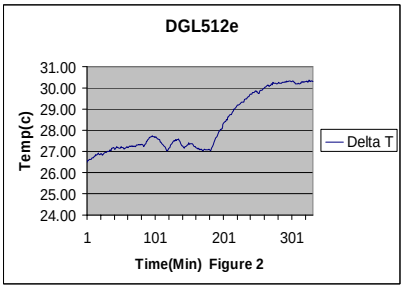


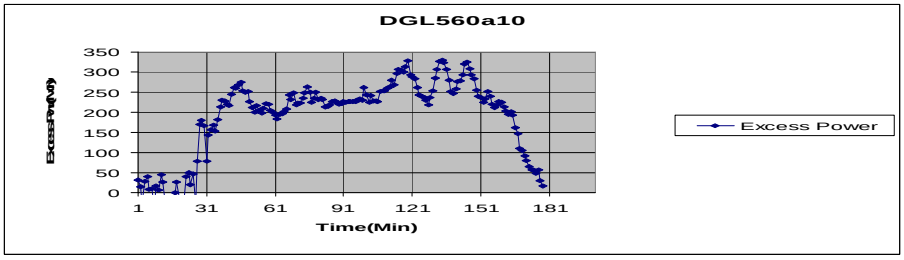
Figure 2

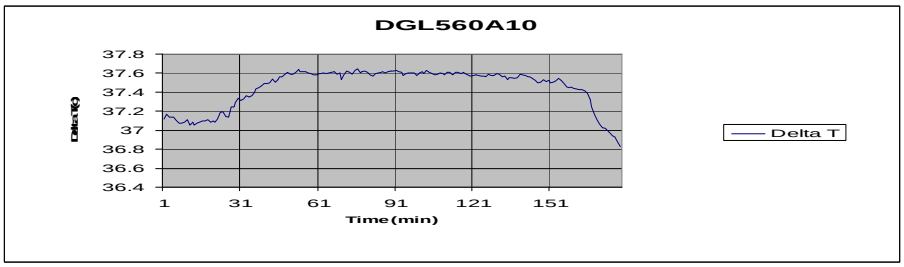
At point 180 two 1 mw laser pointers were switched on and triggered a 3c increase in 75 g of LIOD. Cathode was Palladium and was prepared by the methods discussed in this paper. We estimate that it would require about 600 mw of power delivered to the cell in order to raise the temperature of the cell by 3 degrees.

We soon acquired an ILX Lightwave laser controller, capable of powering and tuning 30 mw laser diodes. We tested several lasers over the 660-665 nm range and the 680-685nm range. Both of these laser wavelength ranges produced excess power when the cathodes were made according to protocol AND plated with Gold after loading during normal electrolysis.

It has been reported that several other researchers have now reproduced this effect.

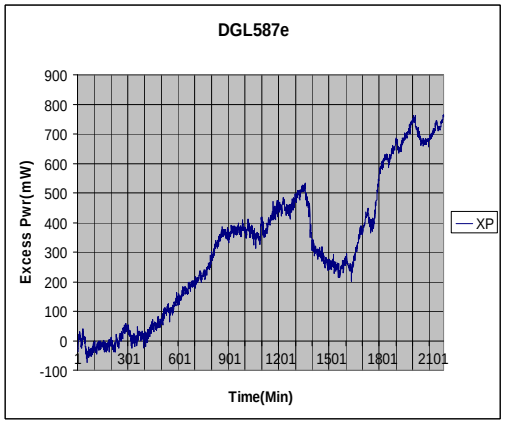
#560a – December 2001





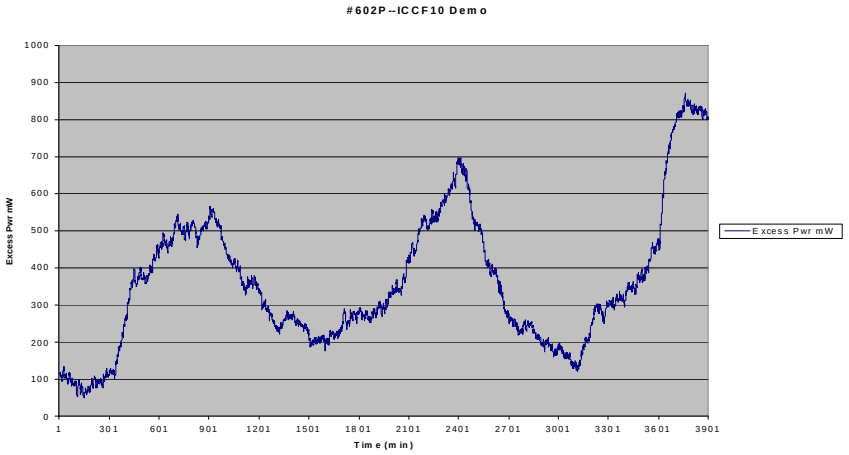
At point 30, a 30 mw laser was switched on and excess power rose to 300 mw; at point 150, the laser was switched off and the excess power signal declined. Each data point is one minute.

#587e – March 6, 2003

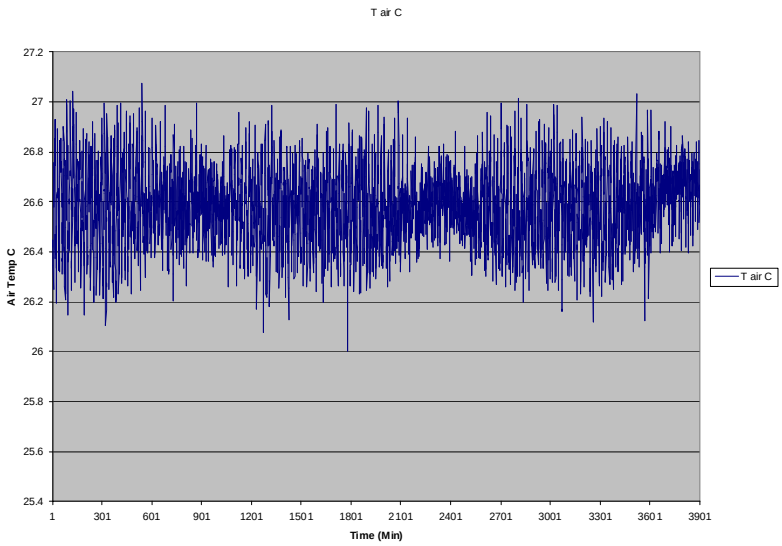


The experiment was witnessed by Miley, Storms, Claytor, Little, Letts and Cravens. The cell made ¾ watt and demonstrated on/off/on properties in concert with a 30 mw laser.

#602 – ICCF10 demonstration

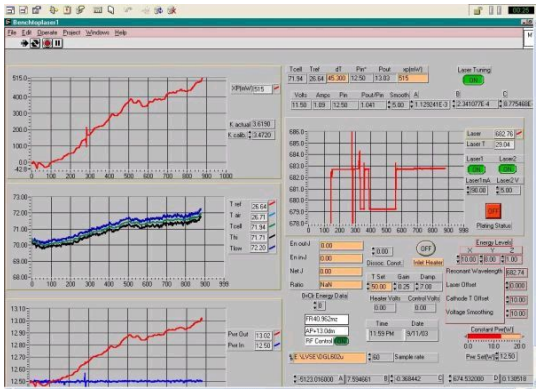


At the ICCF10 conference we demonstrated the laser effect in real time. The 30 mw laser was on continuously and excess power varied from 100mw to 800 mw. Ambient temperature and power were held constant.



Ambient temperature shown above and cell power variations could not have caused the excess power variations observed during the experiment.

After the conference, the run continued



At point 140 the laser was switched on a 682.8 nm; excess power rose to ½ watt in response to the 30 mw stimulation.

What we think we know

The surface: Although we do not speak to all cases of generating excess heat, the laser initiation seems to be at or near the surface of the metal. It is doubtful that the laser is absorbed beyond 100 nm within our samples. The effect has been seen with thin plating of doped Pd over base metals. The effect is affected by the deposition of Au over the surface and the effect seems modified by plating of Pd with the additions of rare earths. All these observations point to the fact that the surface is critical to the effect and that the laser effect is taking place near the surface and not in the bulk of the material.

Base metals can be used: We have had some success using copper, gold or platinum over plated with doped Pd and then plated again with gold. The use of copper as a base drastically reduces the cost of experimentation. The key feature here as in some other experiments seems to be the co-deposition of Pd with D to form reactive sites.

Fabrication methods: What we have presented here are steps that have given our most reliable results. There is no doubt that other methods will work for the preparation of the Pd. There are also times where greater excess heat has been generated. However, they have not been as reliable in seeing excess heat upon laser stimulation.

Laser wavelength and temperature: There seems to be a relationship between the temperature of the metal host lattice and the wavelength needed to trigger the effect. Other researchers have not yet replicated this dependency. This may be a result of the bandwidth of the lasers used or other factors. However, there are runs where we see no excess until the correct wavelength is reached. It is very reassuring to see excess heat response when the wavelength of the laser is altered by only a few nm. It is also hard to conceive of a calorimetric error that is so wavelength sensitive.

High current densities and temperatures: The current density needs to be above 1 amp per square centimeter to see the effect. Although some experiments do yield excess heat below that level, consistent excess needs high levels of current densities. Likewise, the cell temperature must be above 40 C before the effect is seen. This may be due to the wavelength and temperature interdependence.

Lithium Deuteroxide: We did a series of experiments that replaced the LiOD with LiOH. It was clear that the LiOH did not yield any excess.

Laser Polarization and magnetic fields: Our better experiments have been with cathodes that were initially loaded in the presence of an external field. Often the excess heat is dependent on the relative angles between the linear polarized lasers and the direction of the magnetic field applied when the metal was first loaded. Again, it is hard to conceive of calorimetric errors that would change with the rotation of a laser outside the controlled environment or the insertion of a quarter wave optical plate in the beam. The maximum effect coincides with the E field of the polarized laser being perpendicular to the magnet field.

Conclusions

Since this is a workshop, we have sought to give details that will aid others seeking to replicate the laser stimulation effect reported here. It seems there has been little exchange of exact cathode preparation techniques in the literature and yet such information seems to often be a critical factor in producing excess power from deuterated Palladium cathodes.

We have also included some of our raw experimental data in Excel format on a CD for those interested in the details of our work. We hope that others will be encouraged to reproduce the laser stimulation effect in their own laboratories in order to better understand the physics behind the effect.

The laser effect appears to be a promising tool with which to probe the cathode surface for reactive areas capable of producing heat in excess of that expected from the laser alone. The possibility of elemental analysis in those active areas may be especially useful.

Cathode Fabrication Methods to Reproduce the Letts-Cravens Effect

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Dear Colleagues,

We regret missing the workshop but hope our contribution in absentia will be useful.

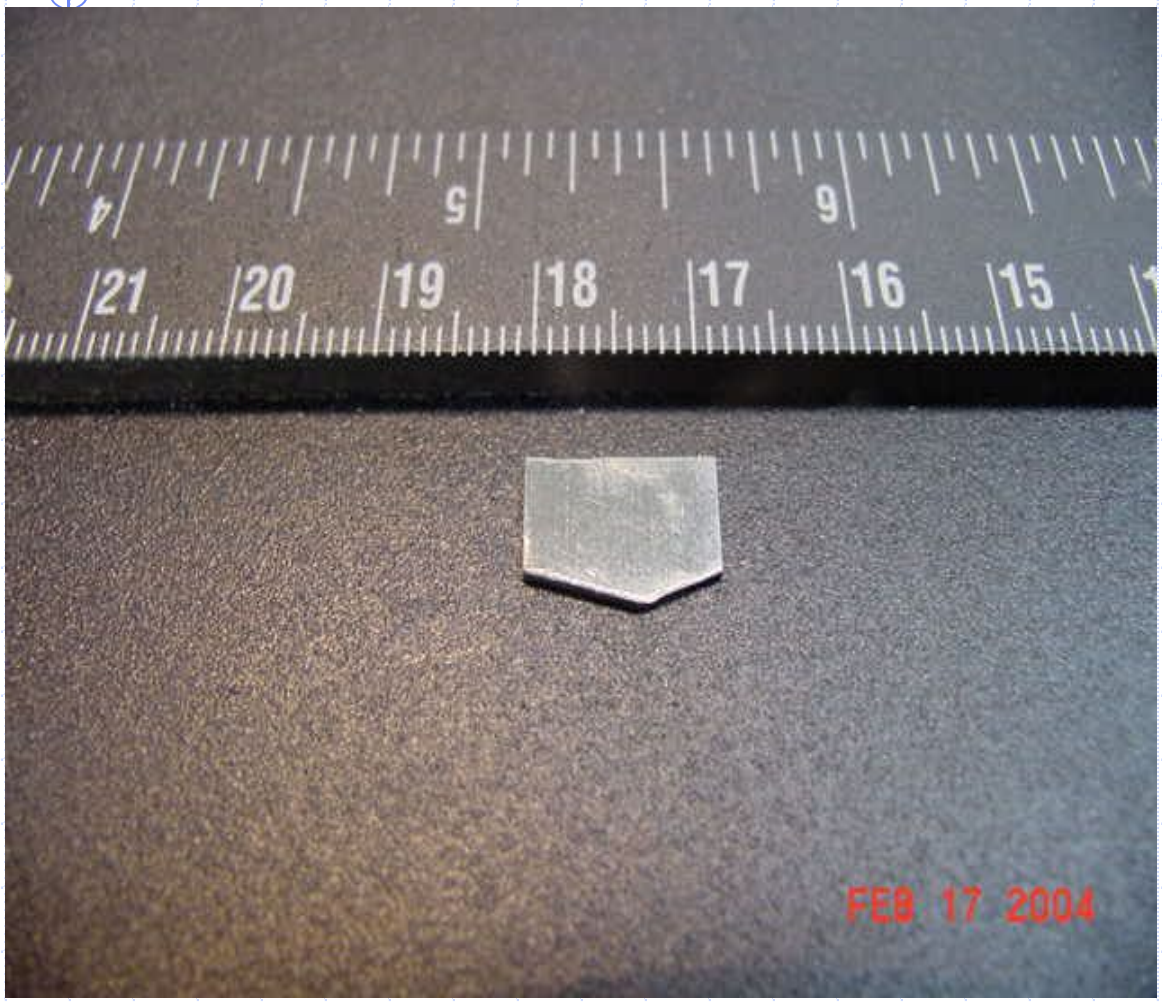
Since this is a workshop, we decided to show all of the detailed steps we use to make a Palladium cathode that will produce excess power when loaded with Deuterium and irradiated with a laser.

We will show graphs from experiments that produced excess power from cathodes fabricated by the methods shown in this presentation. The raw data is available on a CD; see Bill Collis for a copy of the CD.

Best regards to all of you,

Letts and Cravens

Step 1 - The Raw Pd



- **The cathode begins as a billet of .999 Pd 10 x8 x.5mm.**
- **Its origin doesn't seem to matter- we've used Pd from several sources.**

Step 2 - Polish the Pd

- **Our tools and materials are simple.**
- **We use a standard Dremel tool with a fiber brush and a metal brush.**
- **We use Nicksand as a polishing compound—an Aluminum Oxide paste.**

Polishing

- **Apply the compound with a toothbrush and thin as needed with tap water.**

Polishing

- Use the metal brush first and then the fiber brush to make the surface mirror-like.

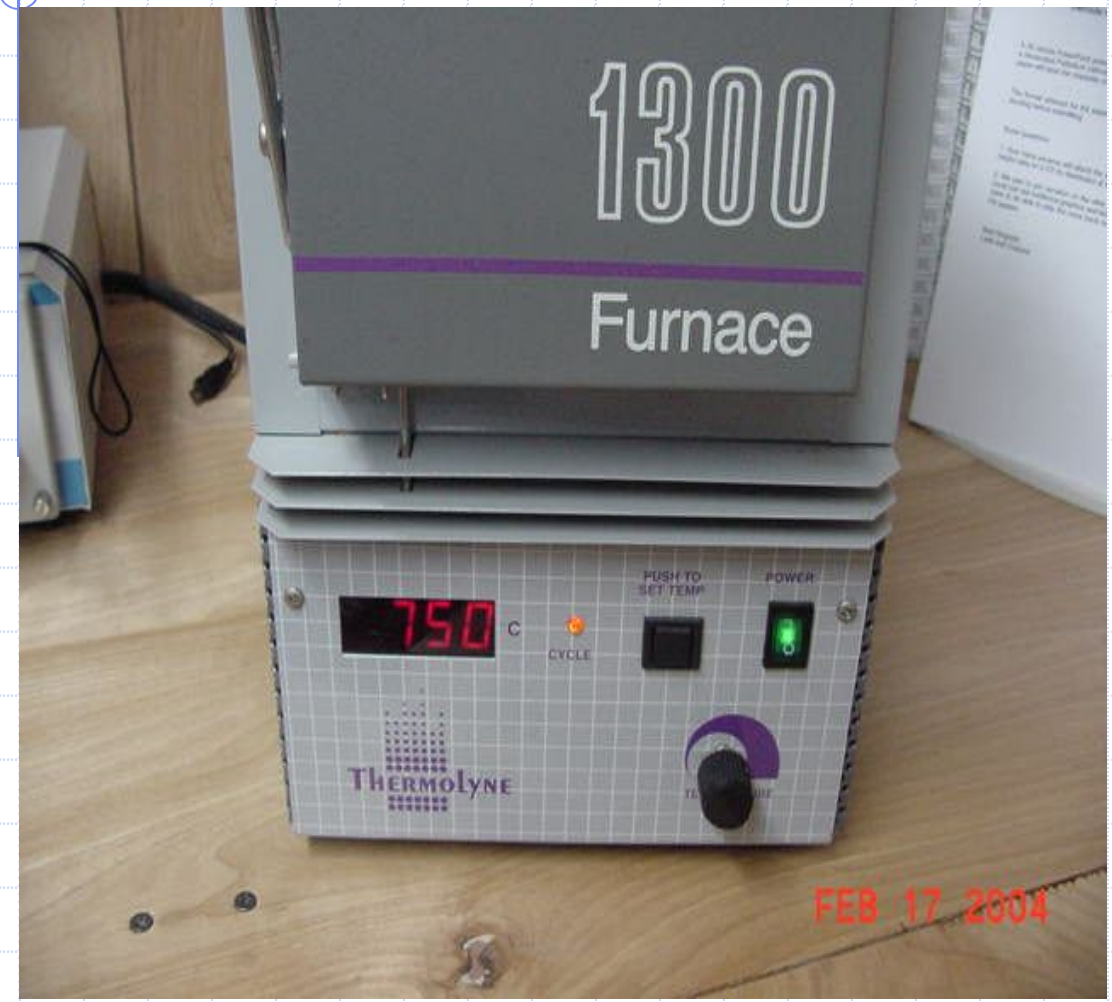
The Slurry

- When the slurry starts to darken, the surface is about right.
- Continue until the surface looks like the next slide.

Step 3 - Rinse work in Tap Water

- **After polishing with the fiber brush for several minutes, the surface will become very bright.**
- **The Pd will be polished a total of four times during the process.**

Step 4 - Heat in Furnace 750 C

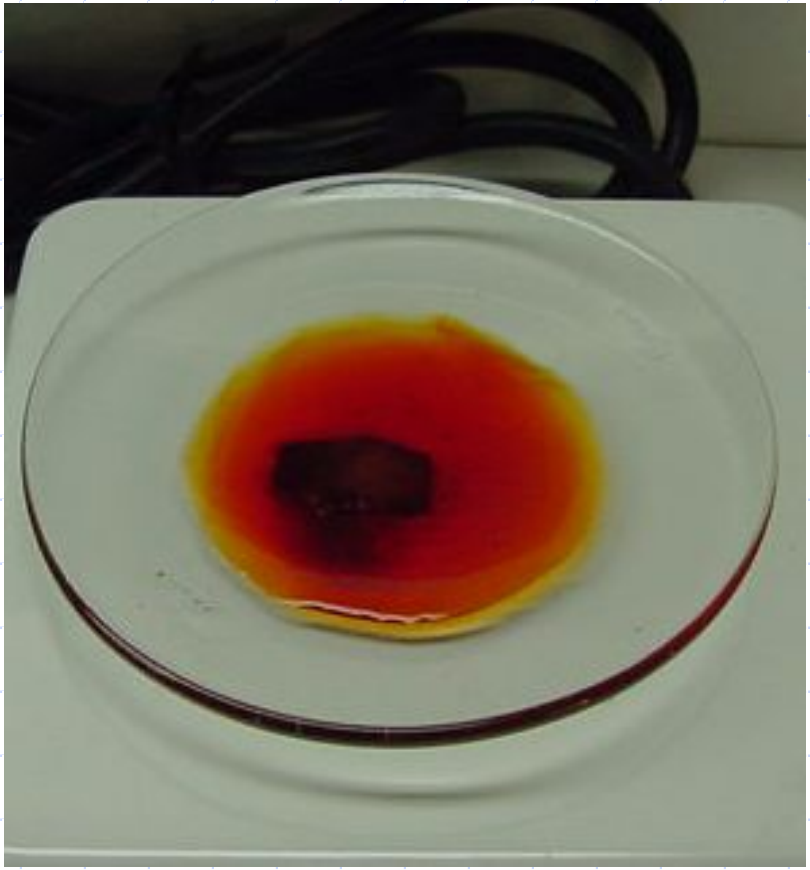


- Place work in a lab furnace for 3 hours at 750C.
- This step is just to clean the surface.

The Oxide Layer

- **After heating to 750c and slowly cooling the work to ambient, an oxide layer will form on the Pd.**
- **This layer will be removed in the next steps.**

Step 5 - Acid Etch



- The oxide layer is partially removed with a 2 minute etch in Aqua Regia, usually at room temperature.
- Sometimes we have etched with acid at 100C to accelerate the oxide removal.

Step 6 - Re-polish the Pd

- Polish again- Begin with the metal brush.
- Follow up with the fiber brush.
- Keep the slurry thin.

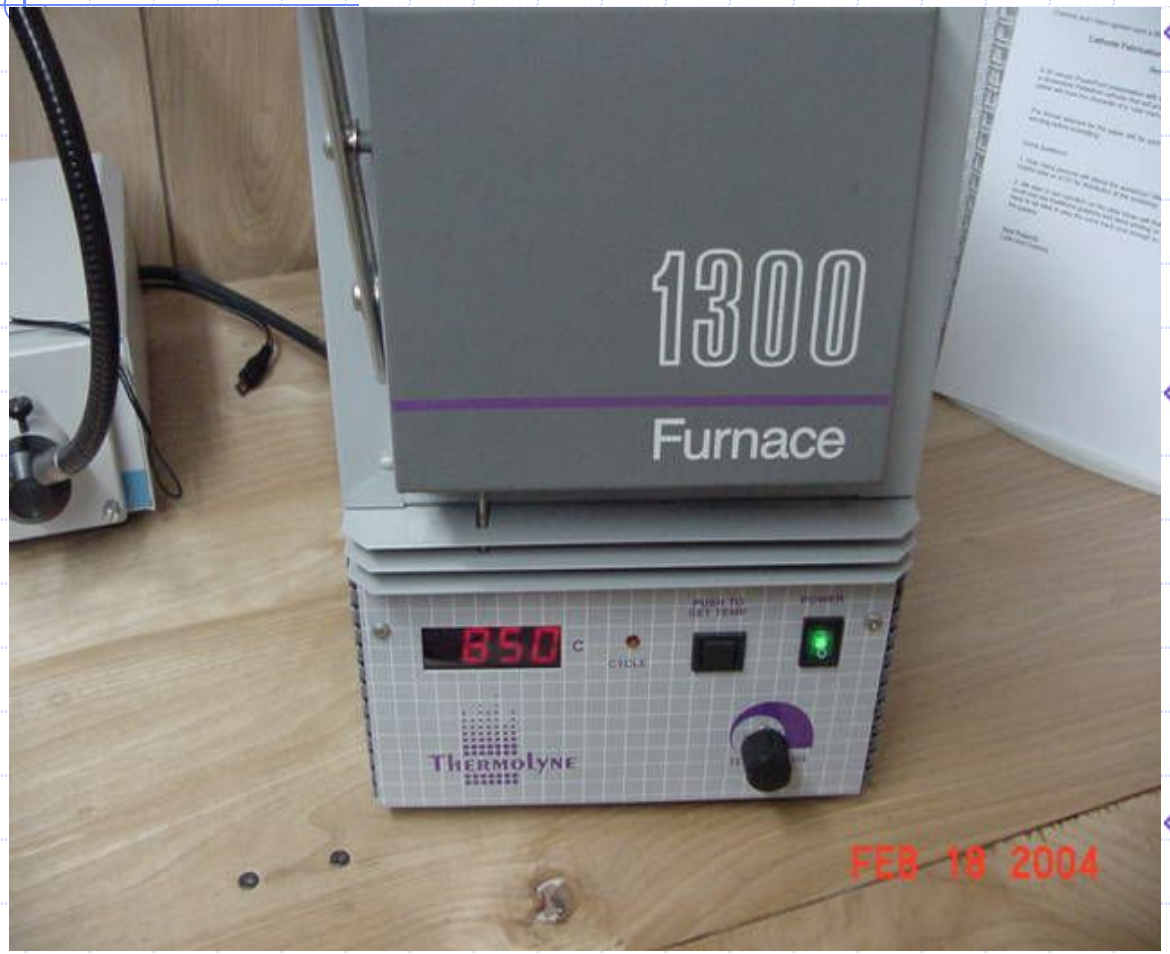
Step 7 - Polish to bright

- When the slurry turns dark, the piece is about ready.
- After several minutes with the fiber brush, the piece is ready to clean.

Step 8 - Ultrasonically Clean

- **Ultrasonically clean for 5 minutes using distilled water only or with general purpose cleaner.**
- **At this step we usually use water only.**

Step 9 - Anneal at 850C



- **The first time in the furnace was to clean the surface.**
- **This time, the 850C temperature changes the crystal structure.**
- **The grain size increases.**

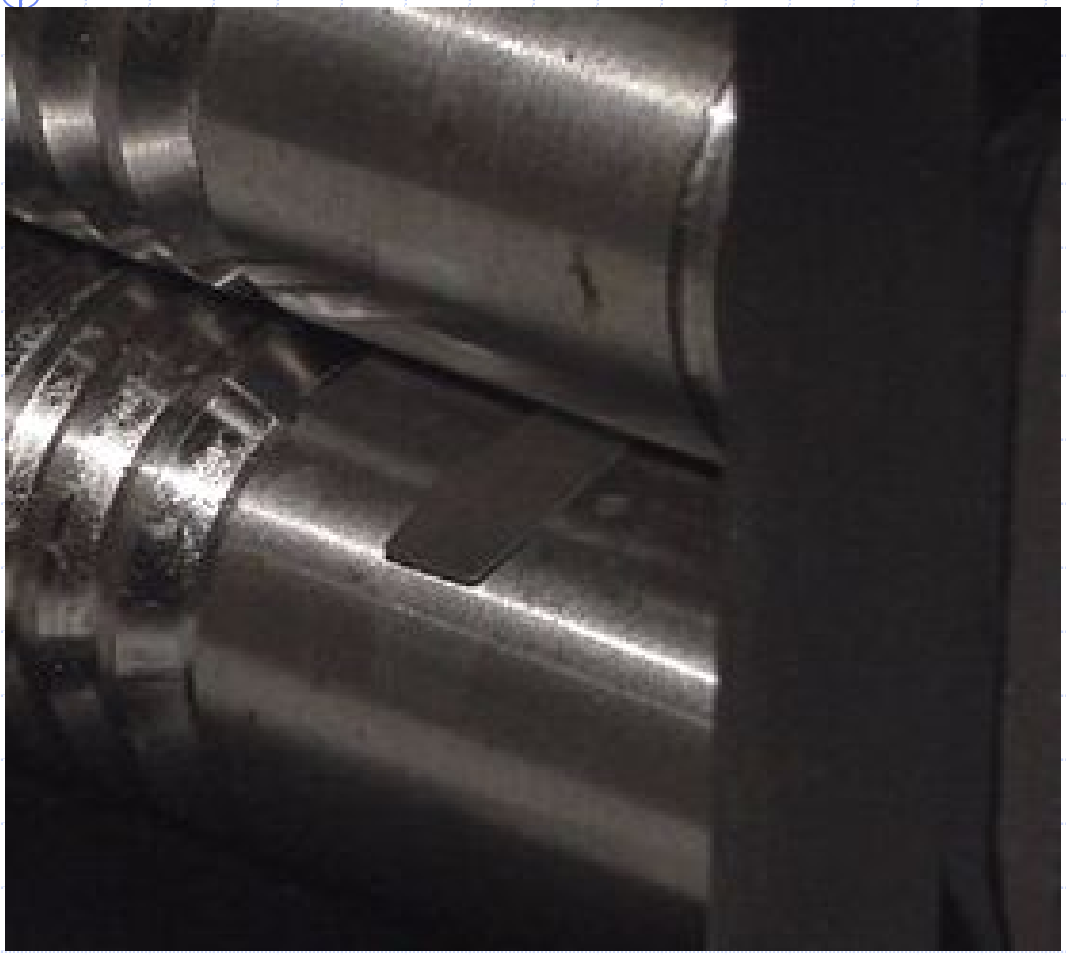
Step 10 - Re-polish

- When the work is polished to bright, the Pd is ready to clean thoroughly and cold-roll.

Step 11 - Ultrasonically Clean

- **Prior to cold-rolling, it's important to get the surface clean.**
- **We use distilled water and either oxide or compound remover.**

Step 12 - Cold Roll



- Using a typical lab cold-roller, we **reduce the thickness of the Pd by about 50%**
- Typically from .5mm to .25mm thickness.
- We make the roll in 4 passes-one pass in each direction

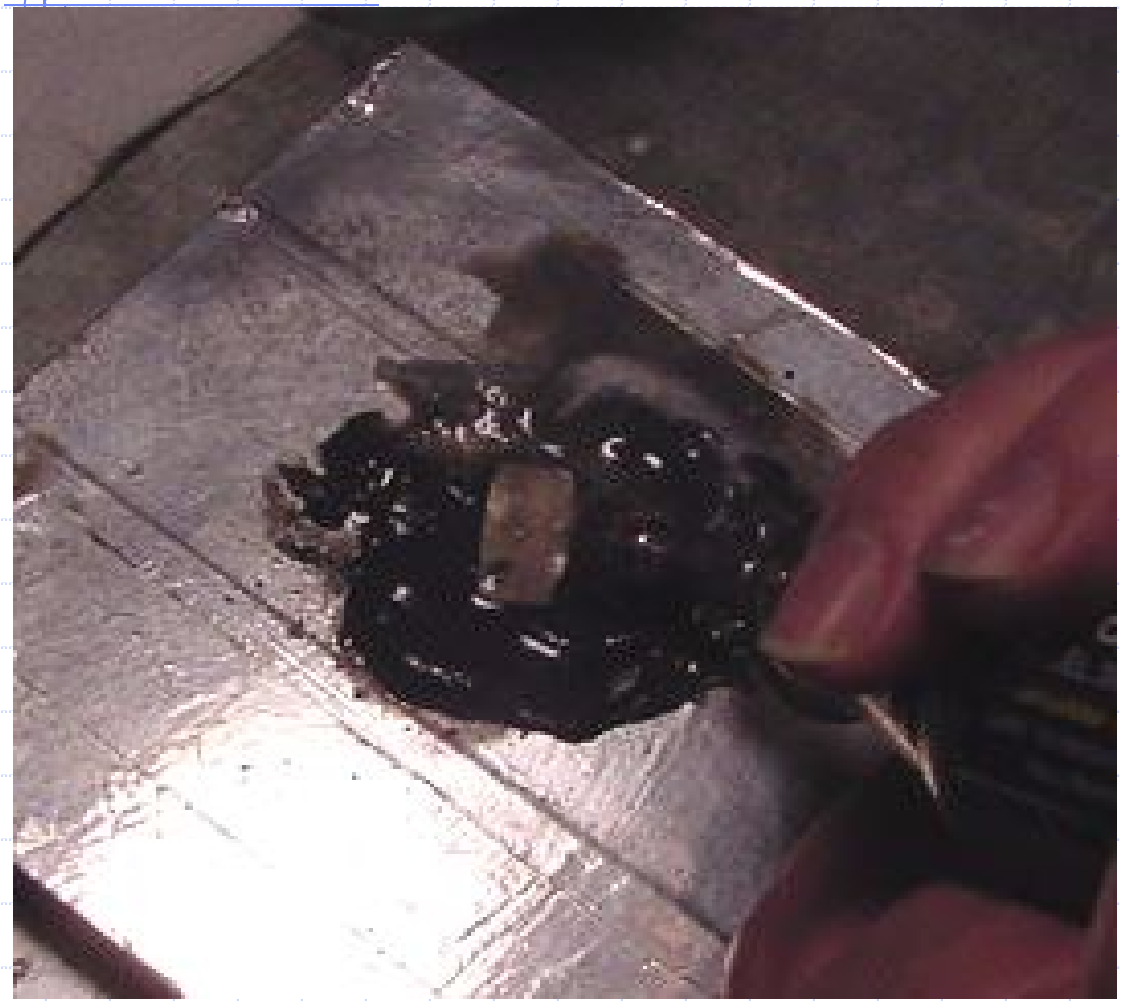
Thickness Check

- We try to end up with a cathode thickness of .20 -.25mm.

Cathode Enlargement

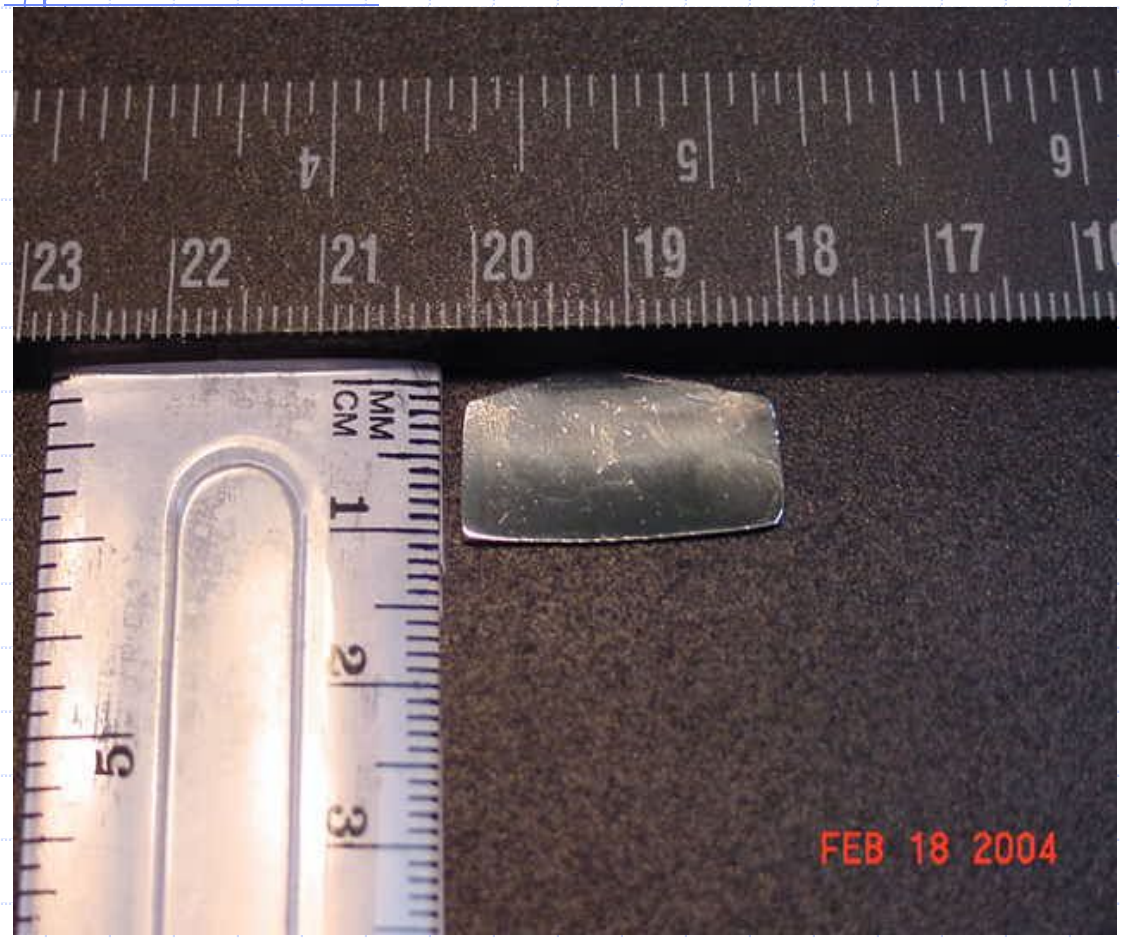
- **After cold-rolling, the surface needs cleaning and polishing.**
- **We note that the cathode is now large enough to make several cathodes.**

The Final Polish



- After cold-rolling, the enlarged piece of Pd is polished with the metal brush.
- Then brought to a mirror finish using the fiber brush.

Step 13 - Polish to Bright

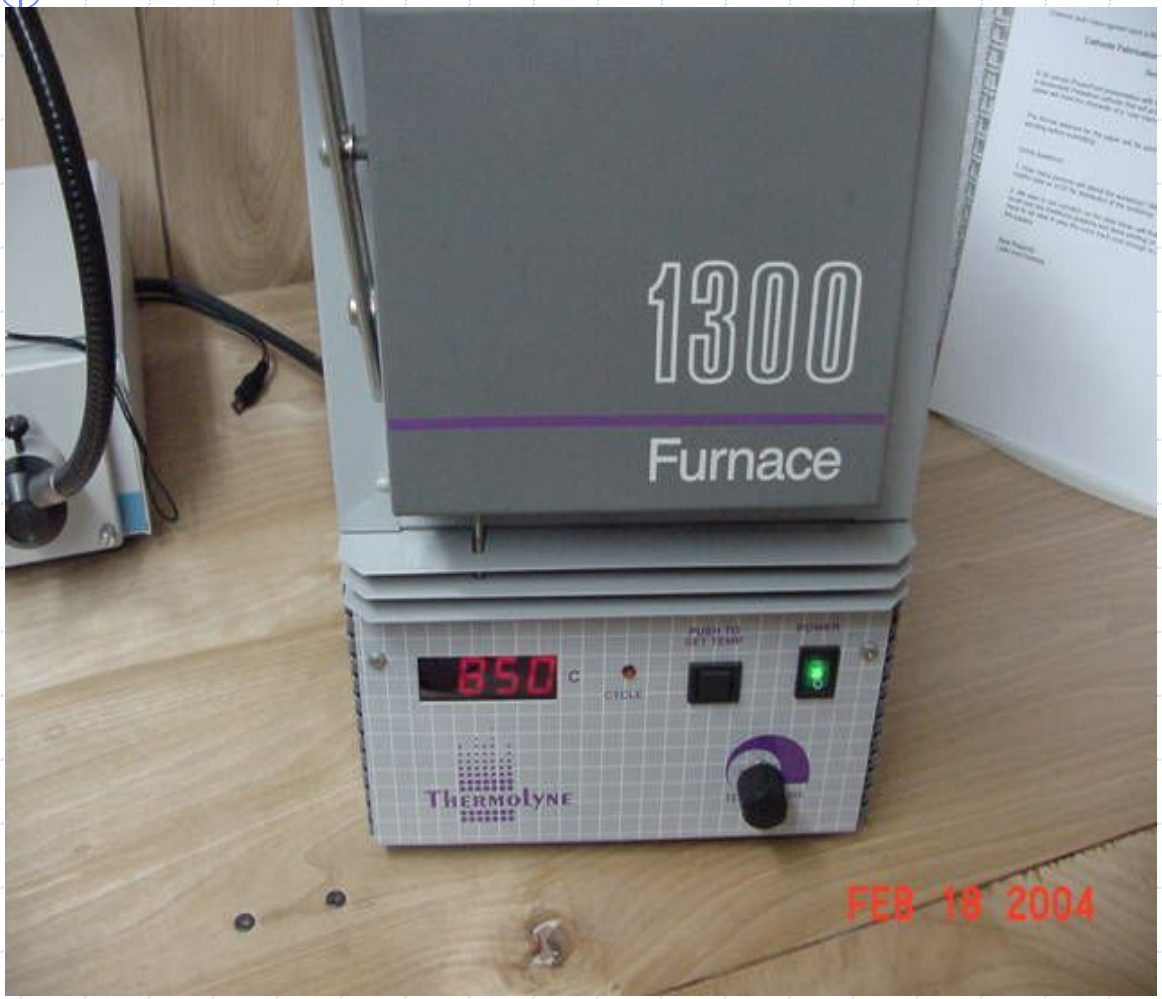


- The cathode is ready for an ultrasonic cleaning and final annealing.

Step 14 - Ultrasonically Clean

- **Following the cold-roll and final polishing, clean in distilled water with a compound remover for 5 minutes.**

Step 15 - Anneal At 850C



- **This is the final anneal; grain size increases more and the stresses from cold-rolling are relaxed.**

Step 16 - Acid Etch

- The entire piece is **etched in aqua regia for two minutes** at room temperature OR at elevated temperature if the oxide layer is difficult to remove
- Max temperature we use is about 100C.

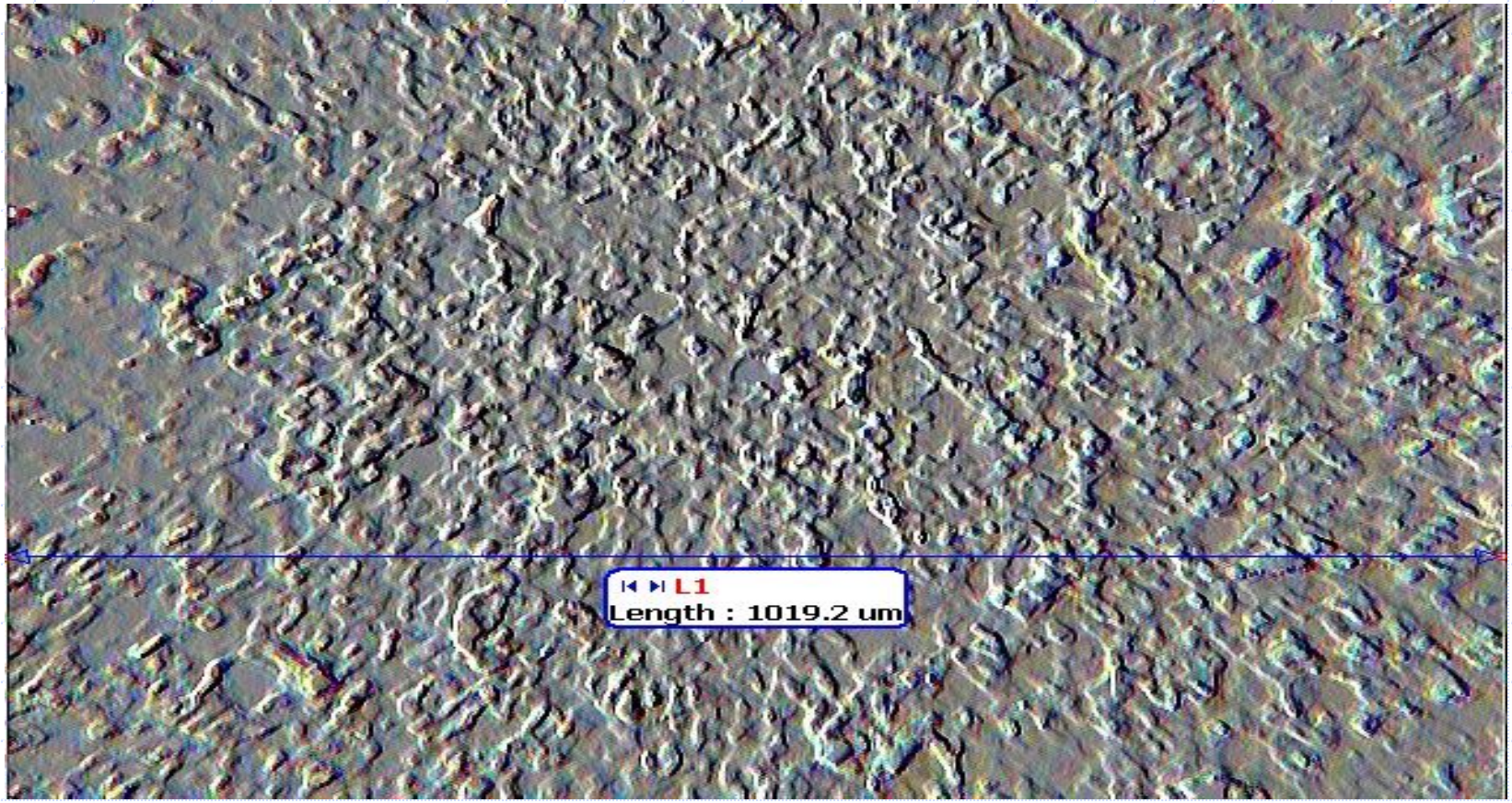
Step 17 - Clean After Etching

- We clean ultrasonically for 5 minutes after etching.
- We normally use compound remover for this step.

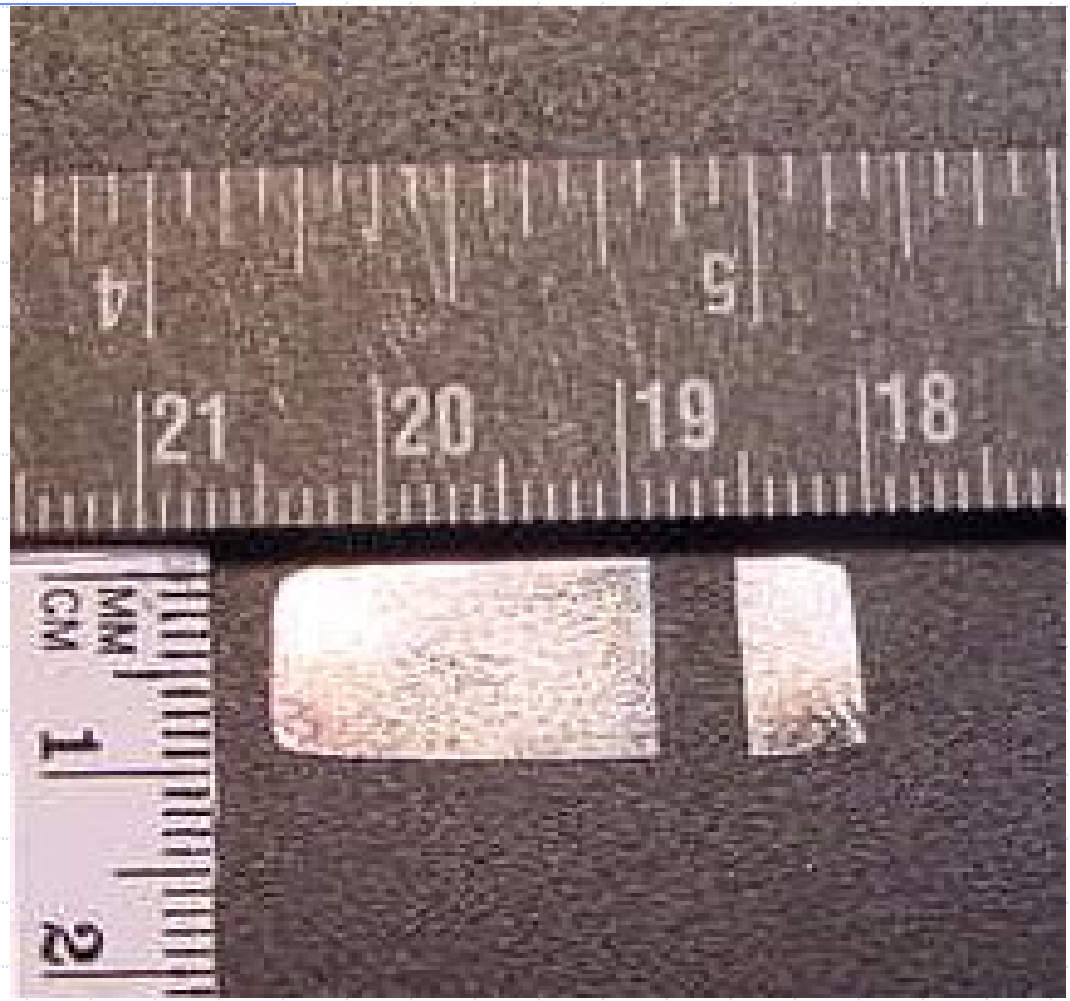
The Finished Surface

- **After etching, the surface will be bright but a matte type finish.**

The Cathodic Surface in Relief View



Trim Work and Cut Cathode



- **We normally make our cathodes about 5 mm wide and 10 mm long.**
- **After the final etch, the cathode thickness is normally about .20mm.**

Clean in Distilled Water

- **You can't be too clean—we usually ultrasonically clean both pieces again after cutting.**

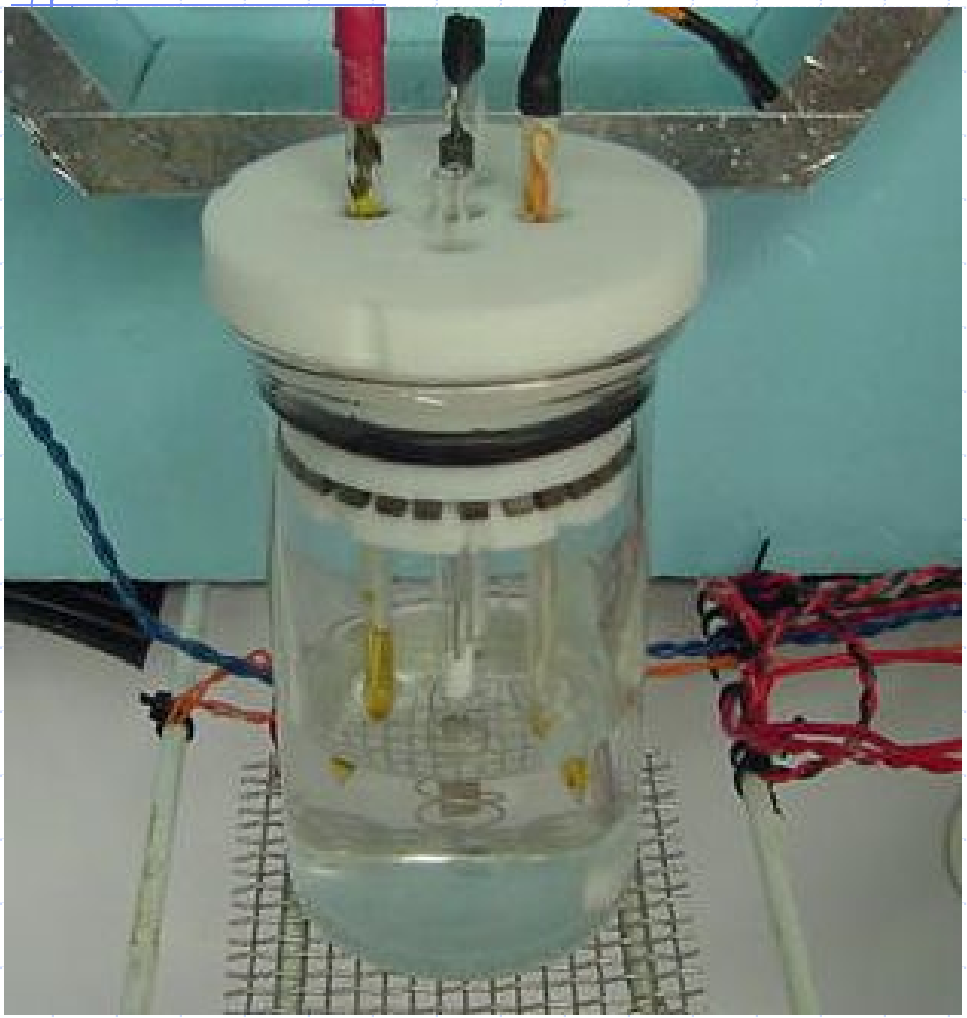
Spot Weld Cathode

- We normally spot weld the cathode to .5mm **Pt hook-up wire**.
- The Pt wire is placed in a 5mm glass tube, epoxied on the top end and the immersed end is filled with Teflon tape to support the wire.

The Anode-Cathode Assembly

- We use a Teflon lid with 5 pass thru's
- The cathode is in the center and the anode is behind the cathode.
- Visible are the epoxied ends of glass tubes and the Teflon taped ends.
- The Pt anode surrounds the cathode with a diameter of 10 mm and at least 3 turns over the cathode.

Add LIOD to Cell

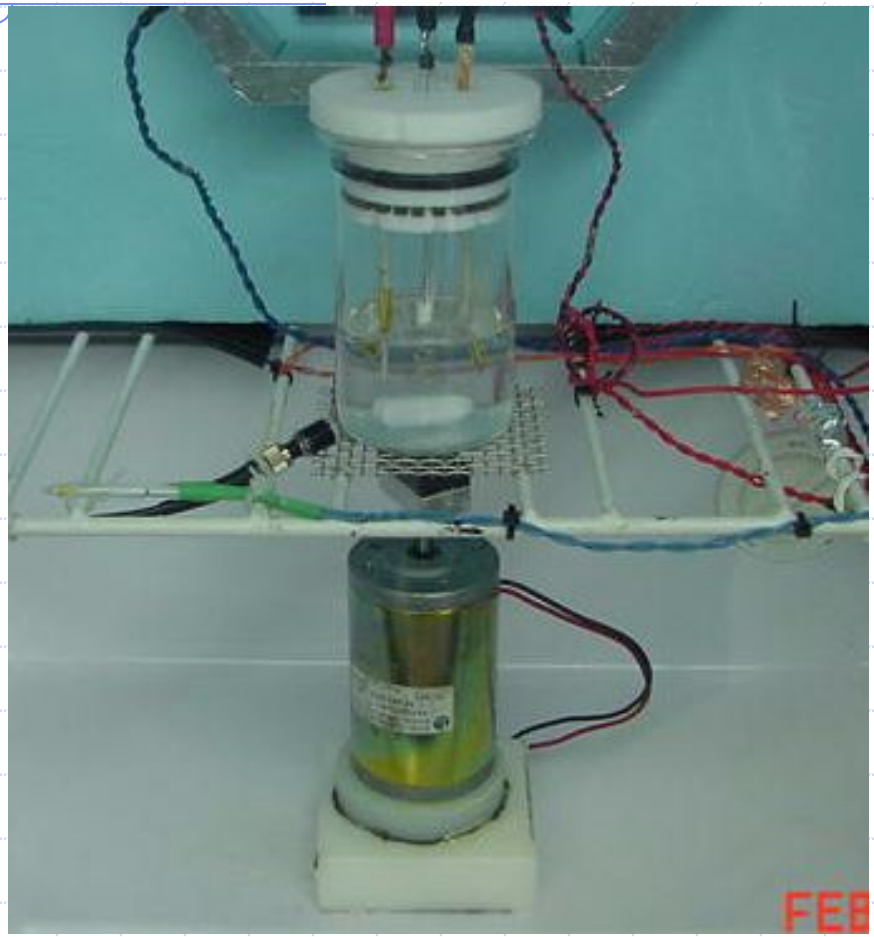


- We normally use 75 g of 1M LIOD for the electrolyte.
- Our cells are closed and we use Platinum Pellets from Alfa-Aesar as recombiners.
- The pellets need to be cleaned before first use.
- Rinse in white vinegar, then in distilled water and final rinse in Methanol.
- Dry with a heat gun.
- They work best above 40c.

Ambient Temperature Control

- **Our experiments are normally conducted in an Avanti wine cooler equipped with multiple fans and a resistance heater to balance against the cooling compressor.**
- **Our data acquisition system controls the box temperature using proportional methods.**
- **Our typical box temp is 25c +/- .02.**

Stirring Option

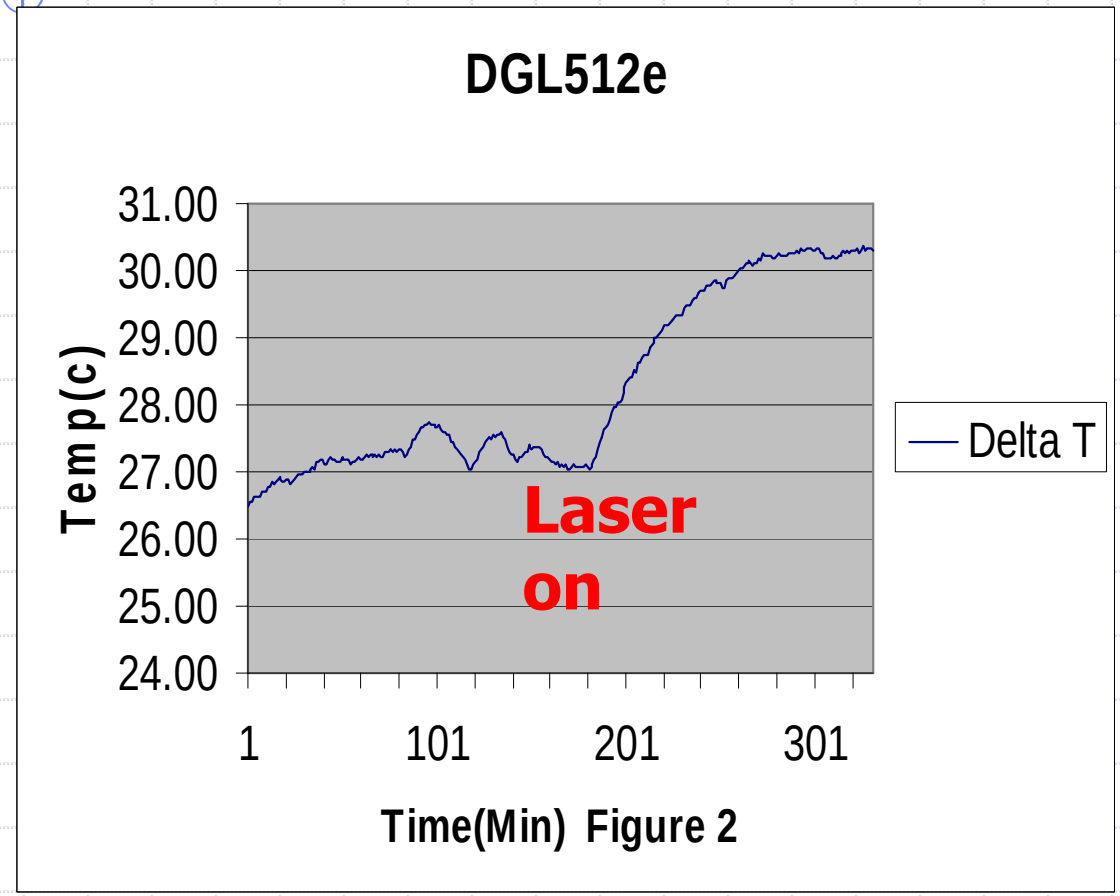


- **We usually run with magnets around the cell, which precludes stirring magnetically.**
- **We provide tight ambient temperature control and constant cell power**
- **This should anticipate most objections to excess power claims.**

Load The Cathode

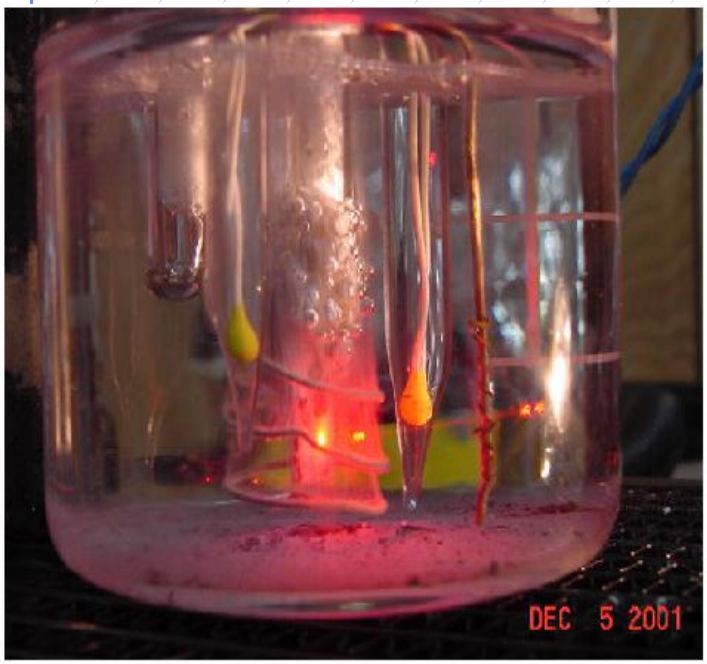
- **We normally load the cathode at a constant current of 0.1 amps for 120 hours (bulk cathodes.)**
- **After loading, cell current is raised to 1.5 amps for 24 hours.**
- **Then Gold is plated in intervals of 10 minutes and tested for laser effect.**
- **If protocol is followed, here's what happens…**

A 3 year history of the Laser Effect



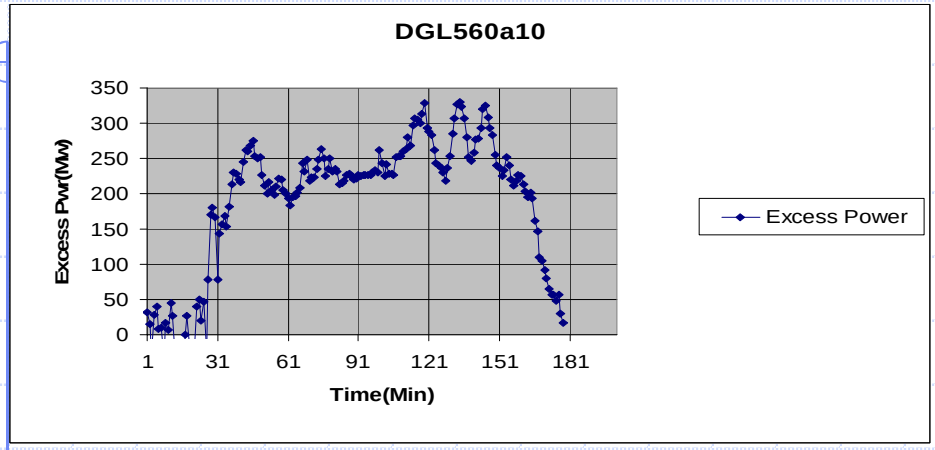
- **The laser effect was first observed in September 2000**
- **Two 1 mw lasers triggered a 3c increase in 75 g of LIOD.**
- **Cathode was Pd and prepared by the methods shown.**

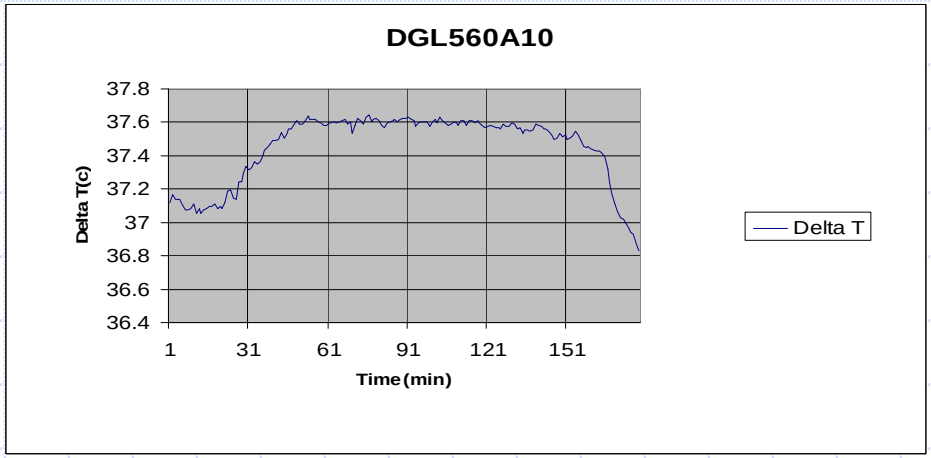
The Effect Repeated Over the Years



- **A red laser operating in the 660 to 665 nm range triggers excess power.**
- **A red laser operating in the 680 to 685 nm range also triggers excess power.**
- **Laser power from 1 mw to 35 mw has been used.**
- **Replications have been reported by others.**

Another Example From December 2001





- At point 31, 30 mw laser was switched on.
- Two hours later, at point 151, laser was switched off.
- Excess power was 10 to 1 over laser power.

Another Repeat in October 2002

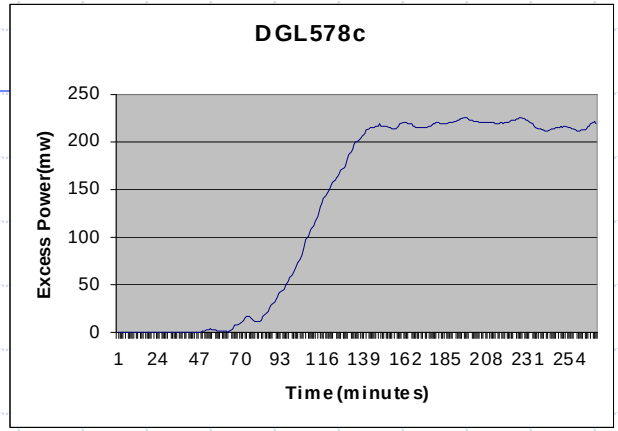


Figure 7

- The top chart shows an excess of 250 mw.

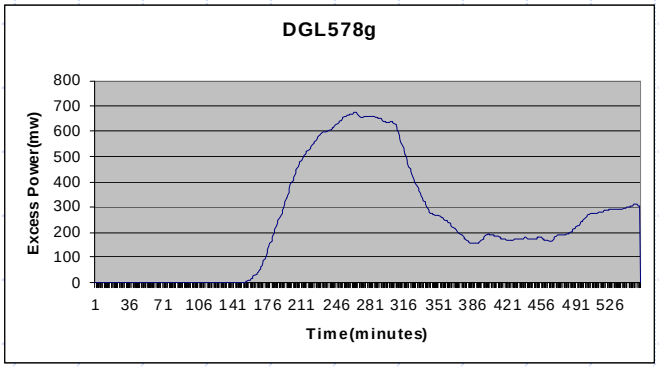
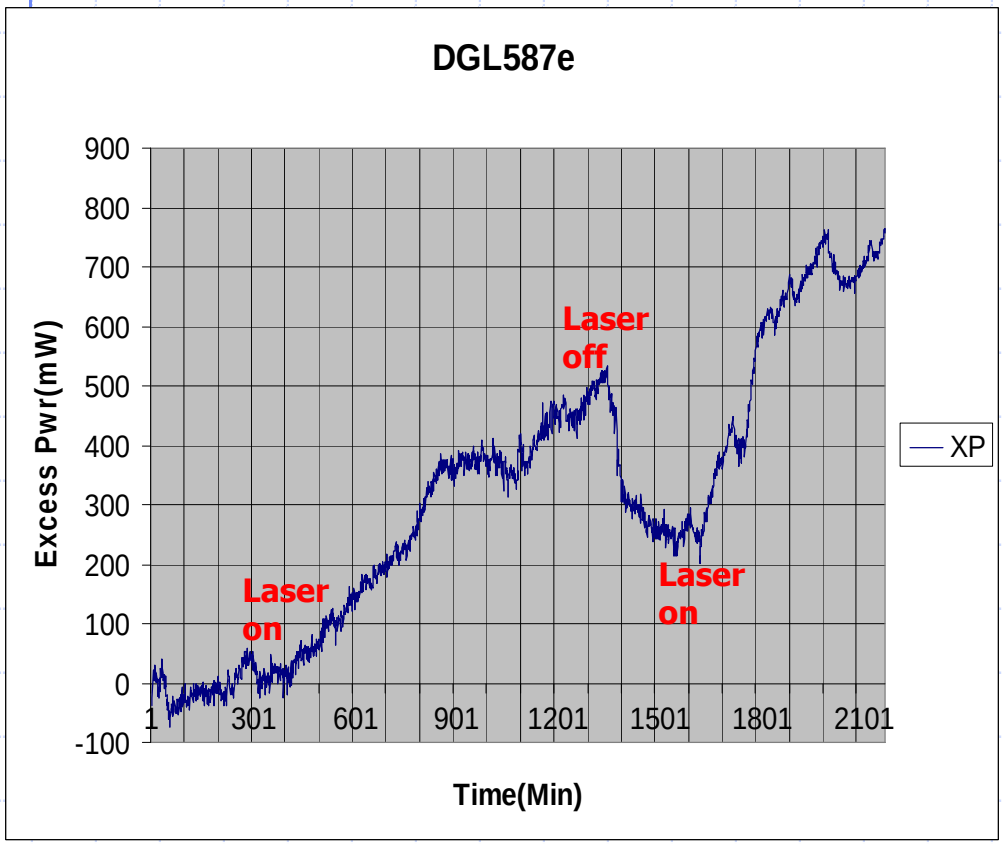


Figure 8

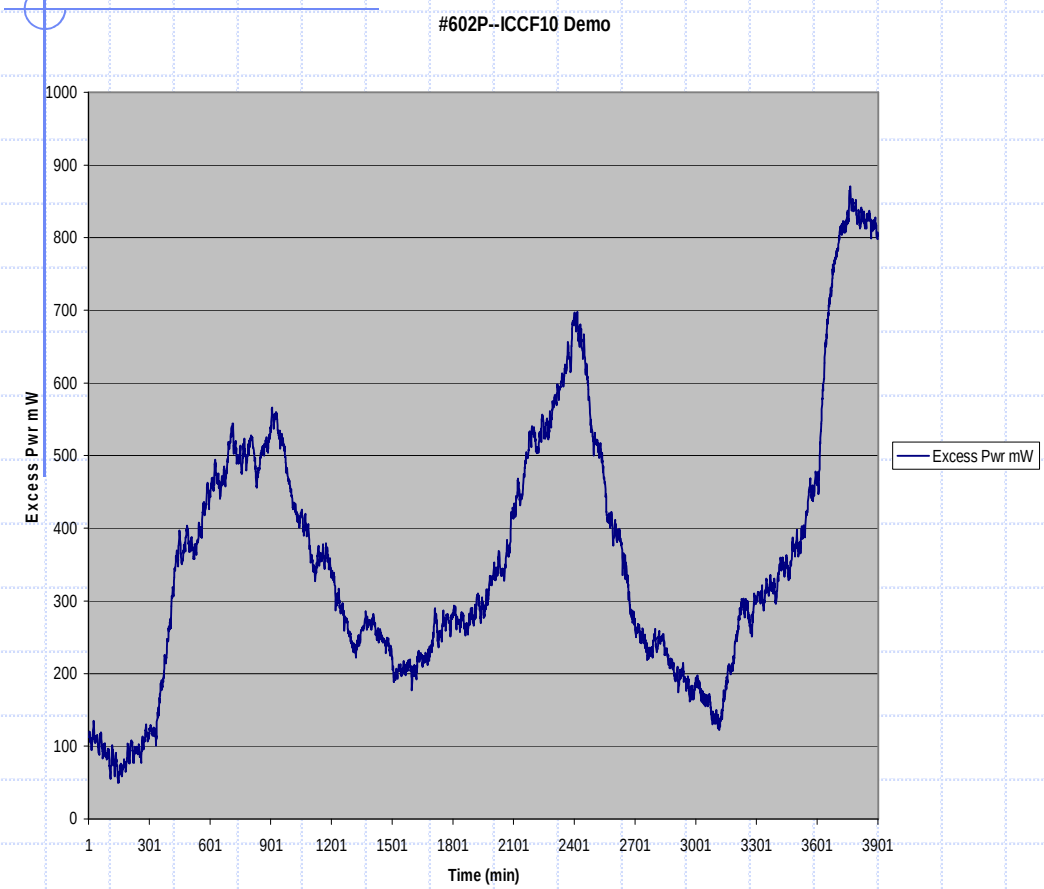
- 24 hours later the laser triggered more than ½ watt of excess power, as shown in the bottom chart.

A Witnessed Experiment on March 6, 2003



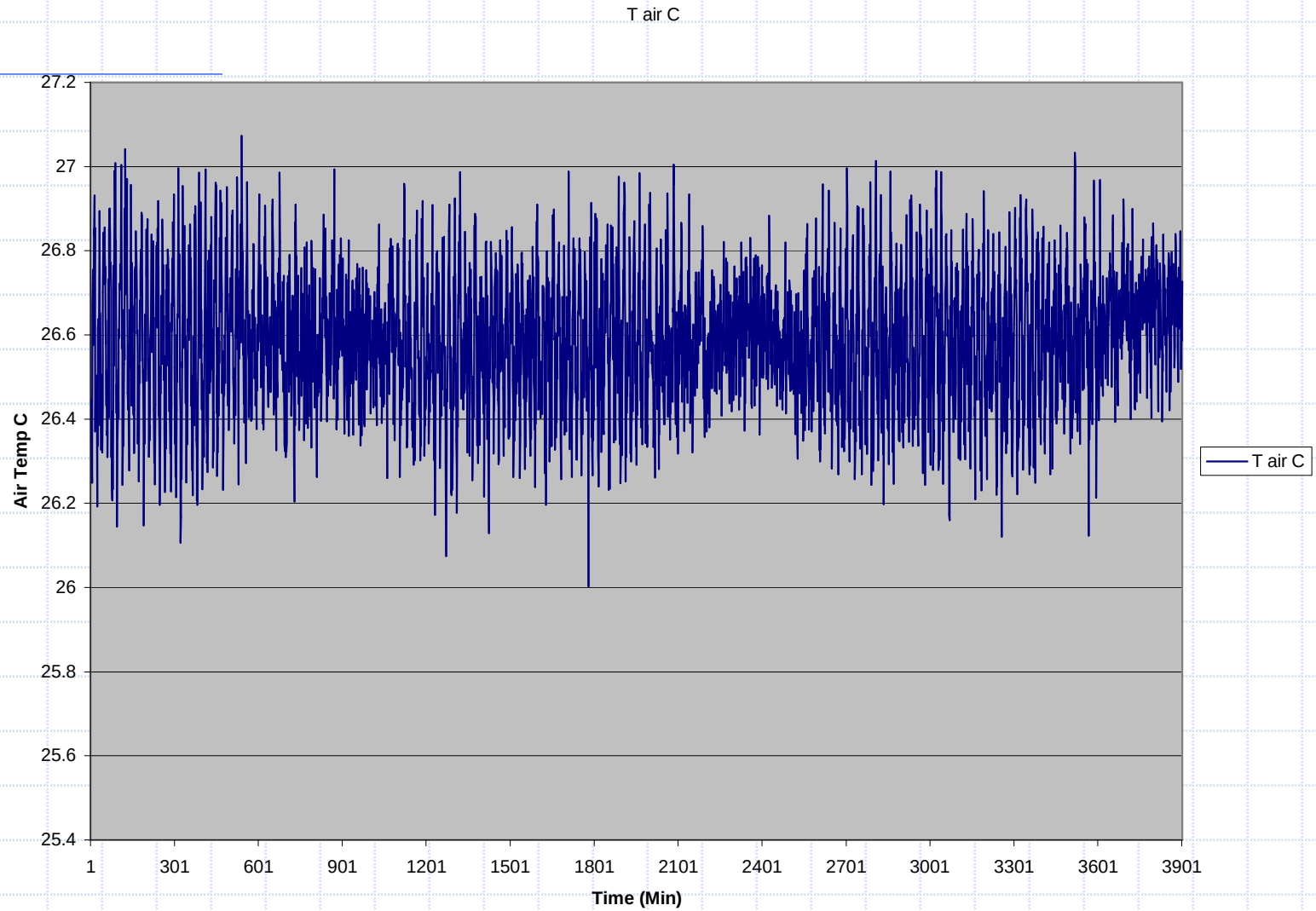
- **This run was made on March 6, 2003 during the APS convention in Austin, Texas.**
- **Witnessed by Miley, Storms, Claytor, Little, Letts & Cravens.**
- **Cell made ¾ watt and demonstrated on/off/on properties in concert with the 30 mw laser.**

ICCF10 Demonstration

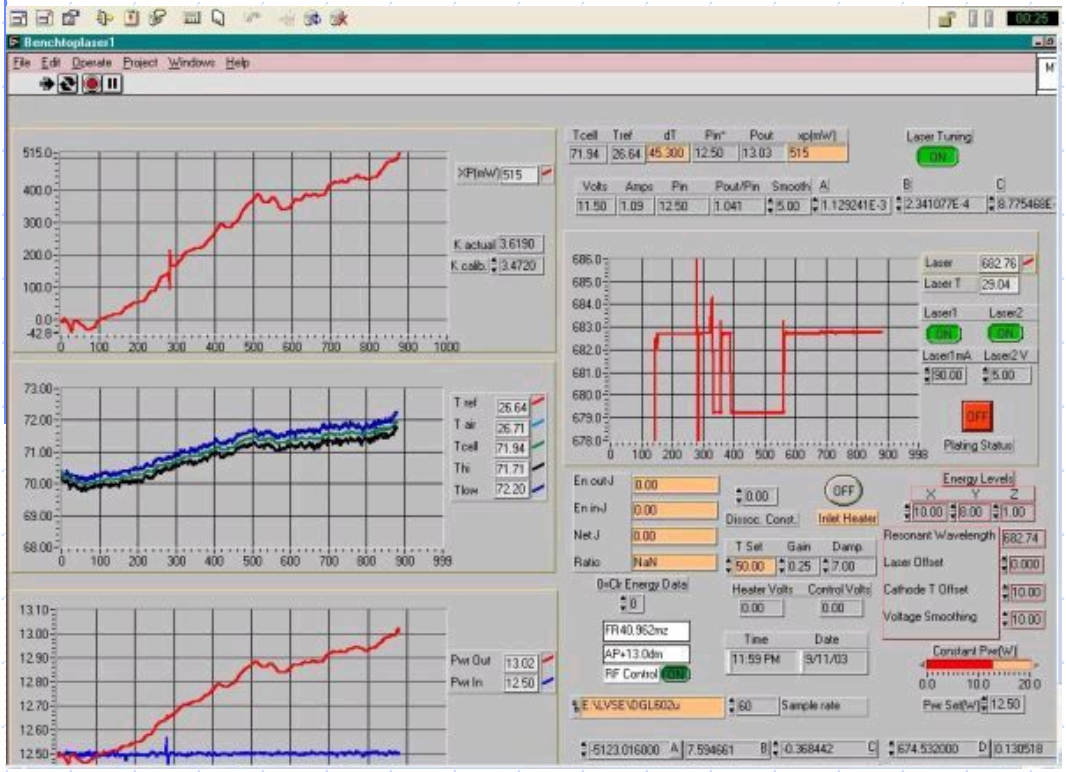


- **At the ICCF10 conference we demonstrated the laser effect.**
- **With the 30 mw laser on continuously, excess power varied between 100 to 800 mw.**
- **As the next slide shows, ambient temperature was held constant**
- **Power was also constant to within 20 mw.**

Power and Ambient Temp Were Held Constant



After the Conference, the Run Continued

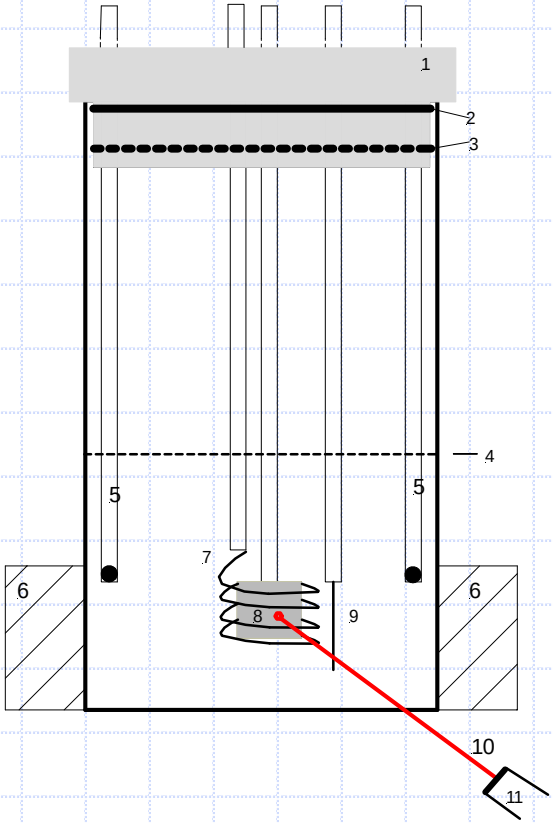


- At point 140 laser switched on at 682.8 nm.
- Excess power rises to ½ watt.

What We Think We Know:

- **Surface is important – follow protocol.**
- **Base metals can be used as substrates – Cu,Au,or Pt plated with Pd and over plated with Au work.**
- **Other fabrication methods may work.**
- **Laser wavelength and cell temperature seem to be important and inter-related.**
- **High current densities and temperatures are required : I >=1 amp and T > 40c.**
- **LIOD shows the effect; LIOH does not.**
- **Laser polarization with respect to an external magnetic field of >=350 gauss is important; appears to go like E x B.**

Cathode Preparation Methods



- We have tried to give you the details of how we make cathodes that respond to laser stimulation.
- Most of what we know has been learned the hard way by collectively performing approximately 10,000 experiments over the last 15 years.
- We wish all of you good luck with your work; contact us by email for any assistance you may require.
- Letts and Cravens

Dual Laser Cell Fabrication*

- Machined Teflon Cell lid
- 7 #8 O-rings
- 1 #327 O-ring
- Cell body - 250 mL Kimax
- Files
- Toothpicks
- Magnifying glass
- 5 mm soft glass tubing (Flint glass)
- Platinum wire for hookup and for the anode
- Small holding vise
- Tack hammer
- Metal plate to serve as an “anvil”
- Small vessel of tap water (to wet #327 O-ring)
- Ceramic bowl to hold recombiner pellets to dry
- Propane torch for heating glass tubing
- Heat gun to dry recombiner pellets
- Ultrasonic cleaner to clean parts & recombiners
- White distilled vinegar

*Photos K. Letts

Teflon Lid, #327 O-ring, Recombiner Pellets

- Wet the #327 O-ring with your finger (tap water)
- Inspect the recombiner pellets - light gray is normal
- All parts should be visually clean
- Rinse the lid in tap water as needed
- The pellets will be cleaned in white distilled vinegar later

Insert Teflon Lid in Cell Body

- Insert a 5 mm glass tube in the center hole (cathode hole)
- Place the end of the tube 1 cm above the cell's 50 mark
- Put a Sharpie mark on the glass tube for cutting

Cutting the 5mm Tube

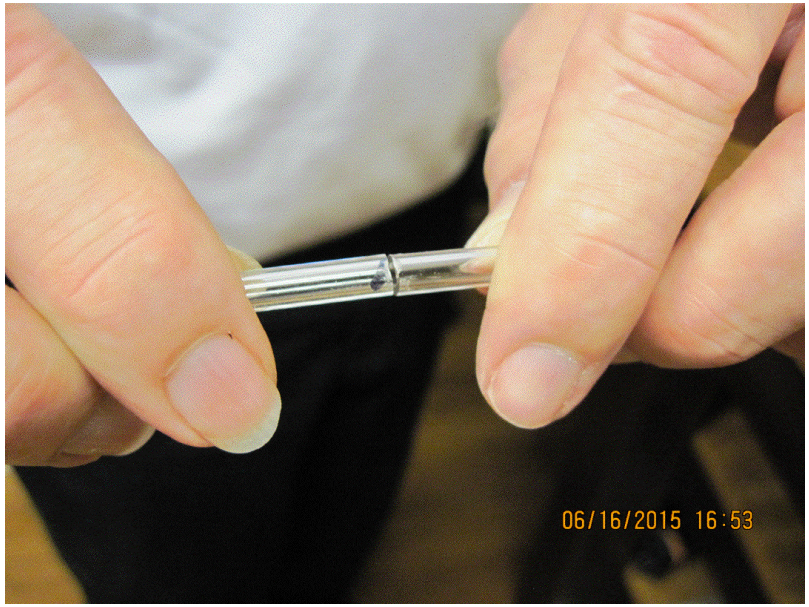
- Place your thumb where you want to cut
- Use your thumb as a brace/guide for the file
- The file will make a scratch on the glass tube

Scratching the Glass Tube with a File

- Brace the file with your thumb
- Scratch an observable line in the glass tubing
- Ten file strokes is about right

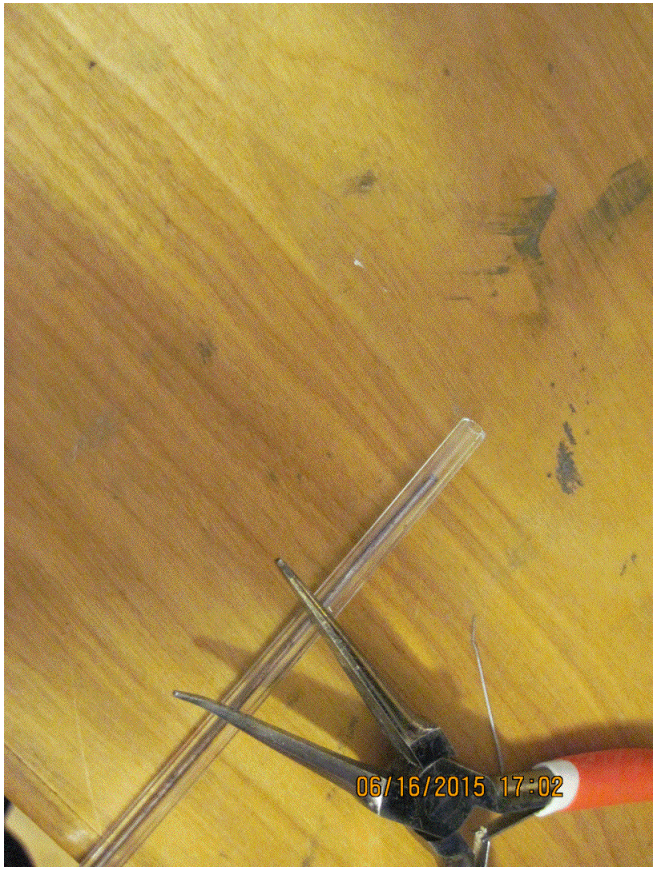
Breaking the Glass Tube

- Gently bend the tube at the scratch mark
- Tube should snap easily
- If not, scratch the line more with the file



Marking the Glass-Platinum Seal

- Use a 1/16 inch rod inside the glass tube
- This saves platinum wire
- Place the end of the rod about 1 cm from tubing end
- A platinum wire will be spot-welded to the metal rod
- This wire will pass through the sealed tubing end



Preparing Metal Rod for Spot-welding

- Flatten the metal rod on the end
- This makes it easier to spot weld
- Flat surfaces spot-weld easier than round surfaces

Preparing the Spot-Weld

- Select a 0.5mm platinum wire
- Clean the wire with a propane torch
- Use needle nose pliers to hold wire
- Wire can be straightened during torching
- Use a second pair of pliers to put wire in tension
- Torch the wire in tension and wire will straighten
- Position the wire in the center of the flattened rod
- Gently rest the welder tips* on the wire to hold it

*** Best to use Tungsten tips instead of copper**

Making the Weld

- Apply moderate pressure to the spot welder handle
- This force will hold the wire in contact with the rod
- Apply a short burst of current (1/2 second or less)
- Observe the glow at the weld
- The spot welder will have a switch to apply current
- Most models have a timer to set the weld duration
- Use of a holding vise is recommended
- You can rest the spot welder on boards to adjust height

Preparing the Glass Tube for Wire-Glass Seal

- Insert the metal rod into the 5mm tube cut previously
- Position the rod to leave at least 1 cm of pt wire at end
- Jam a toothpick in the opposite end of the tube
- This secures the metal rod in the glass tube

The Platinum Wire in the 5mm Glass Tube

- Purpose is to seal the platinum wire to the tube
- This will make an airtight seal
- Centralize the platinum wire in the glass tube

Use of the Variable Speed Drill

- Insert the glass tube in the drill & tighten chuck
- Don’t over-tighten the chuck
- Light the propane torch
- Placing the torch on the floor works well
- The bench is OK too

Heating the 5mm Tube

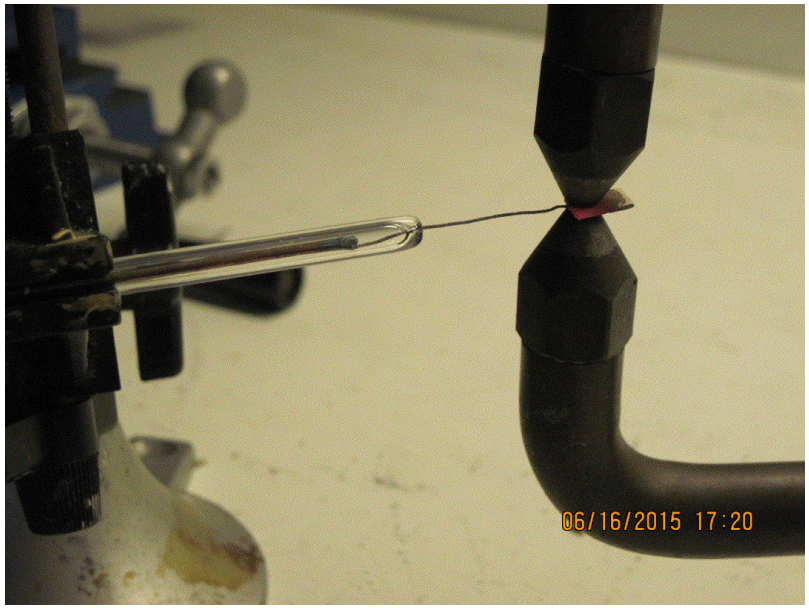
- Begin turning the tubing at medium speed
- Insert the end of the glass tube in the flame
- Gently move the tubing left and right through the flame
- Keep the tube in the flame “a while”
- You will learn by experience how long “ a while” is
- Do NOT remove the tube to inspect the seal
- Why? Because you can’t cool the tube and re-heat
- The tube will likely crack
- So just keep rotating the tube to make sure it’s sealed

Check the Seal

- A good seal will be clear and slightly green-tinged
- The green tint comes from the soft glass
- The softened glass will completely surround the Pt wire
- No gaps, rounded tip at the glass-wire interface
- No cracks in the glass around the wire
- Why this works: soft glass & pt wire expand similarly

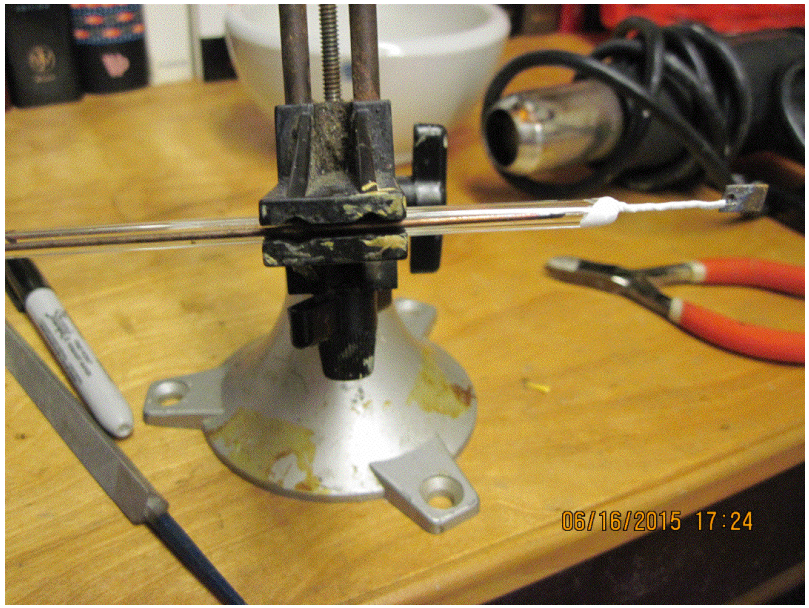
Spot-Welding the Cathode to the Wire

- This wire is longer than normal
- 1 cm is typical
- Center the platinum wire on top of the cathode
- Use a small holding vise
- Adjust the welder height using boards
- Gently press the welder tips to hold the piece
- Apply a short pulse of current - maybe 1/2 second
- Observe a small amount of reddening around the weld
- This is OK
- Don’t over-weld.
- This can make the piece stick to the tip
- Don’t over-heat the cathode - small red glow is OK



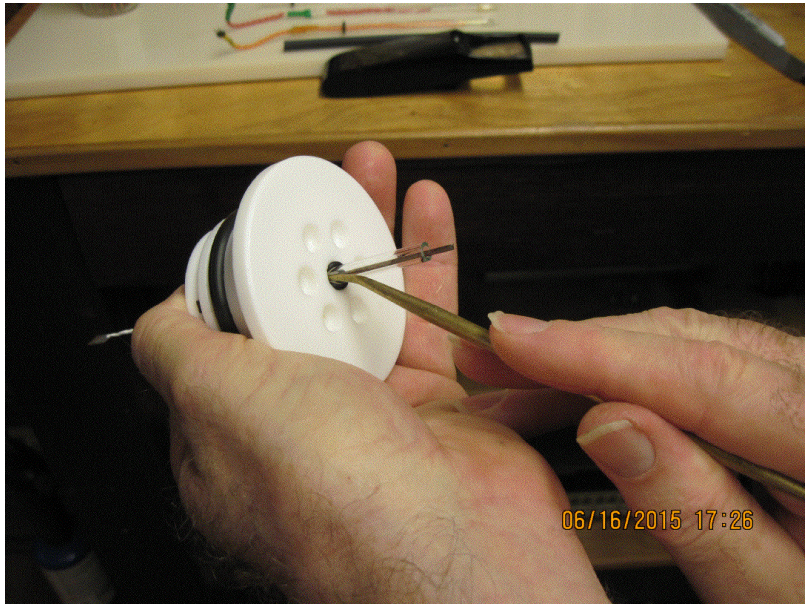
Teflon Taping the Cathode Hook-up Wire

- Wrap Teflon tape around the platinum wire
- Why? To avoid loading deuterium into the Pt wire
- Yes, deuterium will load into the platinum
- It doesn't form a deuteride like palladium
- We want all the deuterium to enter the palladium cathode
- Note the cathode is scrap from the lab
- A real cathode would be pristine
- This one is just for convenient demonstration



Insertion of Electrodes into the Teflon Lid

- Using a brass O-ring tool, seat the O-ring seal
- Cathode typically goes into the center hole
- Glass tube can be slide up or down to adjust height
- The tube and rod can be cut off if too long
- A Dremel works well for this purpose
- Seal the end of the tube with epoxy - like JB Quick
- Solder electrical connector to the rod
- In-line connectors from Digi-Key work well
- Male connectors are used on the cell side
- Female connectors are used on the power supply side
- During handling, avoid touching the recombiner pellets
- Finger grease causes them to work inefficiently
- They can be re-cleaned using white vinegar
- Apply with a toothbrush in-situ
- Rinse carefully with running tap water
- Dry with heat gun



Inserting Anode into the Teflon Lid

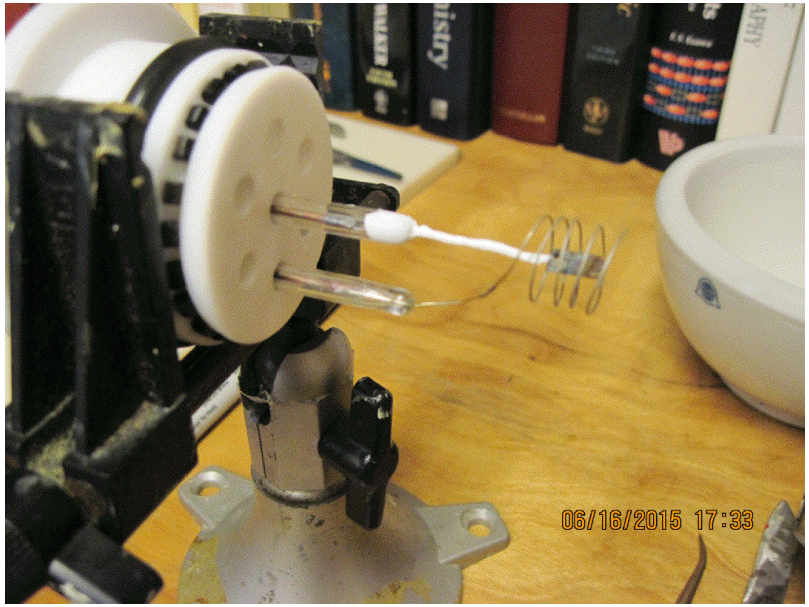
- Place the lid in a holding vise
- Insert the anode in any hole
- Behind the cathode is best
- This position avoids blocking the laser beams
- Note the male in-line connector on the anode holder
- Note the JB quick epoxy
- Tip: don’t epoxy the electrode holders too early
- Leave the electrodes open until the glass-wire seal step

Forming the Anode Coil

- Cut a piece of plastic tubing about 2” long, 1/2” OD
- Place the tube around the cathode to form the coil
- Make at least five turns over the length of the cathode
- Centralization of the cathode is important for good loading

Anode-Cathode Assembly

- Make sure the cathode is inside the anode wire cage
- The anode wire does not need to be Teflon wrapped
- All platinum wires should be covered by electrolyte

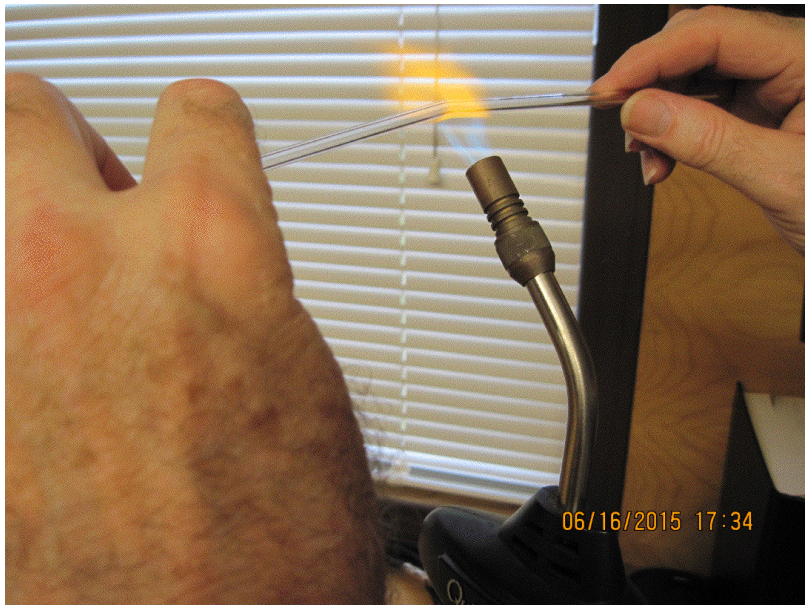


Cathode Centralization in the Anode Cage

- Cathode must be centralized within the anode
- This causes deuterium to load evenly in the cathode
- Uneven loading leads to cathode bending
- Bending means cathode stress
- Stress creates leaks
- Avoid long cathodes because they bend easily
- Make sure the anode wraps are not too close
- Why? To provide laser access to the cathode

Making Thermistor Probes

- Called “Pulling Points”
- Mark the glass tube with a Sharpie
- Rotate the glass tube to distribute the heat
- When ready, the glass tube will bend slightly



Closing the Tube

- When the glass tube bends, quickly pull it apart
- The tube on the right is usually the “keeper”
- Use the scrap tube on the left as a tool
- Touch the tip on the right to pull and shape the tip
- You can also rub the glass tip on the torch tip for shaping

Shaping the Point

- You can shape the tip so it is sharp or blunt
- A tip with moderate sharpness is best
- Excessive sharpness leads to breakage
- After a few attempts, it will be easy to do

Finished Thermistor Probe

- Thermistor is connected to 24 gauge wire
- Potted in thermal transfer paste
- Note that the thermistor leads are stagger cut
- This means the leads are different lengths
- This avoids shorting the leads in a tight space
- If bare, one lead must be covered with a small sleeve
- Best to get Teflon-covered thermistor leads
- Then just stagger cut the covered leads
- This thermistor was made using bare leads
- Note the small diameter yellow tube sleeve
- A single male in-line connector is used
- Hook-up wire from the thermistor is made by hand
- Use two strands of 24 gauge wire
- Put one end of both strands in a vise
- Put the other end of both strands into a drill
- Start the drill; the strands will twist together
- This will form a long twisted pair very easily
- 6 ft is a typical length
- Use a female in-line connector on one end (Digi-Key)
- The other end is left unterminated

Recombiner Care & Handling

- Recombiner pellets must remain clean
- Before first use, clean ultrasonically 5 minutes in vinegar
- Clean ultrasonically for 5 minutes in water
- Rinse in running tap water
- You can also clean them in-situ if required
- Use a tooth brush with vinegar
- Rinse carefully with water
- Dry with a heat gun on low

Recombiner Installation/Removal

- Pellets are handled with tweezers
- Blunt tipped tweezers work best
- Pellets can break - so rock them a little for removal

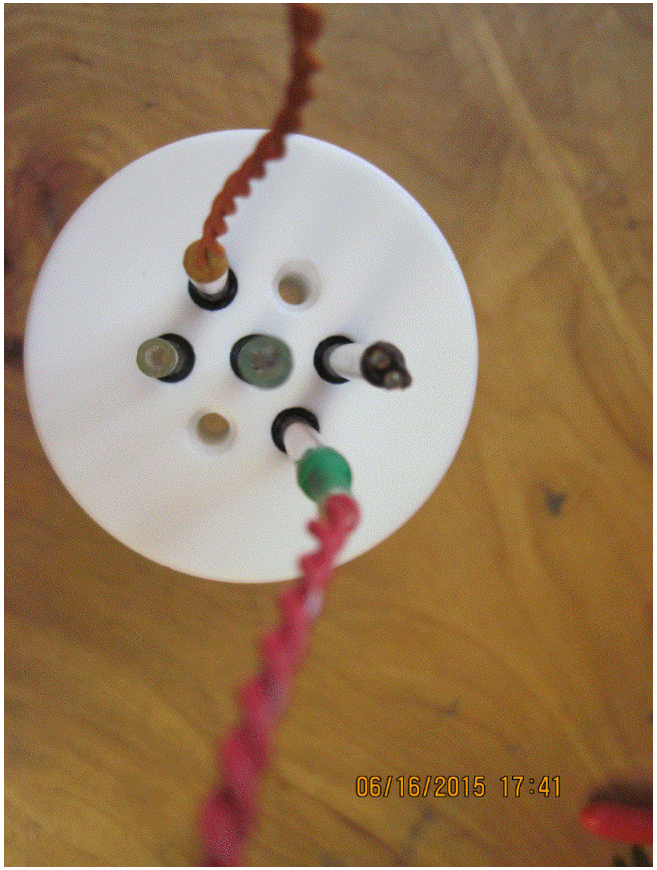
Seating Recombiner Pellets

- The tweezer handle is used to seat the pellets
- Press gently until the pellet is secure
- It’s best to leave a little space behind the pellet
- Space between the pellets is also recommended
- Recommend filling the entire groove with pellets
- Only a few pellets are active up to about 2 amps
- More amperage requires more pellet activity
- These pellets start to work well about 50C
- They work best at 100C
- If they are kept clean and warm, they will work well
- They will last for months
- When they turn white, clean them in white distilled vinegar
- After many cleanings, discard the pellet.
- A bottle of recombiner pellets can last 1-2 years

The Finished Cell

- Note the front of the cell is open for laser access
- Note the left thermistor is slightly below the cathode
- Note the right thermistor is slightly above the cathode
- The cathode is centered on the 50 mark of the cell
- Fill the cell with LiOD at a concentration of 0.3M*
- Keep all cell parts very clean
- Nothing inside the cell except:
- Pt, Pd, glass, Teflon, gold for in-situ plating*

* **These items will be covered in a separate slide set**

Top of the Cell & Pass-Throughs

- Center hole is the cathode
- Hole at 3 O’clock is the anode
- Hole at 9 O’clock is the vent
- Hole at 10 O’clock is thermistor 1
- Hole at 4 O’clock is thermistor 2
- Open hole at 2 O’clock can be for the gold electrode
- Open hole at 8 O’clock is for heater or can be plugged