Lattice Energy Converter (LEC)

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http://www.inovl.com

Here is a YouTube video of this presentation with voice-over

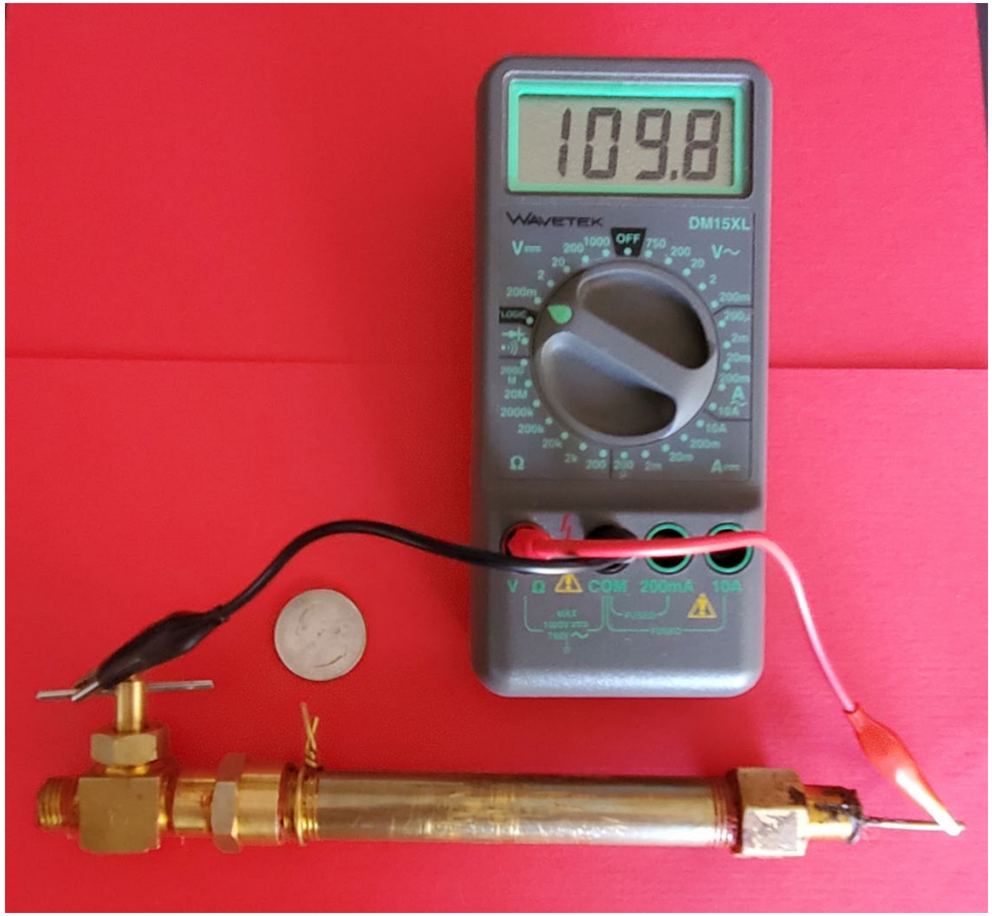
Presentation Note

Let me start by thanking the organizers of this workshop for taking the initiative to honor Dr. Srinivasan in this manner. He was one of the most respected members of this community for his knowledge, his contributions and also his personality. We are honored to make this presentation in memory and honor the legacy of Dr. Srinivasan.

A Lattice Energy Converter (LEC):

- **Will spontaneously initiate the production of ionizing radiation and electrical energy based only on the thermal energy in its palladium lattice that is occluded with hydrogen or deuterium**
- **Produces sustained ionizing radiation and electrical energy when the lattice material is in fluidic contact with a gas containing hydrogen or deuterium**
- **Does not require naturally radioactive materials**
- **Mechanically simple to construct and test but the physics of its operation is not fully understood**
- **Easy to replicate**

Extraordinary Claims Require Extraordinary Evidence



A LEC cell producing spontaneous and self-sustained electrical energy for several months into a DVM with a 10 MΩ input impedance

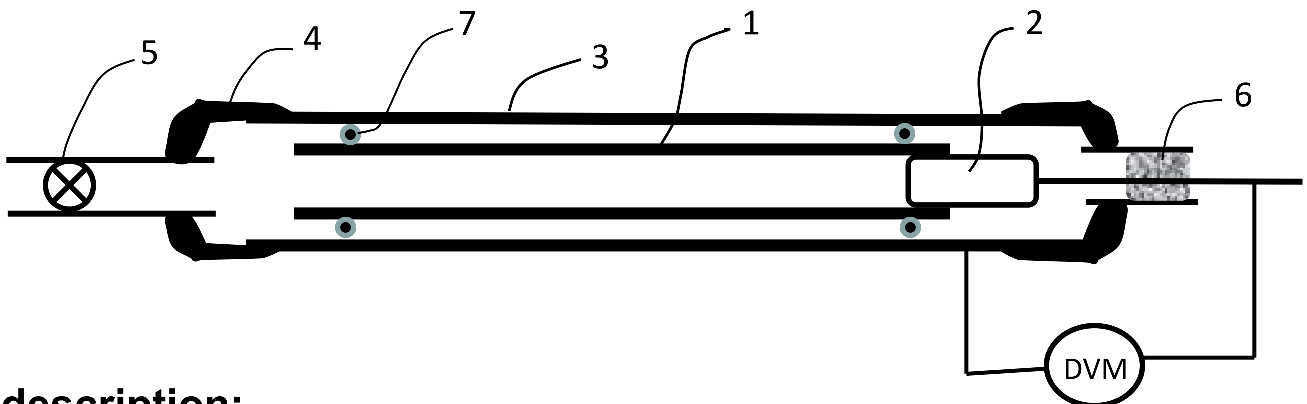
A lattice energy converter (LEC) is a complex device from many perspectives: physics, mathematics, electrical engineering, thermodynamics, and material science. Shown is a LEC cell connected to a DVM with a 10 MΩ internal impedance. The cell consists of a Pd working electrode codeposited from an aqueous (H_2O) PdCl2 and LiCl solution. A brass counter electrode coaxially surrounds the working electrode and is positioned so that it is electrically isolated from the inner working electrode. The cell was evacuated after which hydrogen ($^1H_2$) gas was introduced into the cell, typically raising the absolute pressure to between approximately 500 to1500 Torr, and the valve is closed. The DVM was connected and a spontaneous voltage was measured. If no voltage had been measured, the cell would be disassembled and additional Pd codeposited onto the electrode and the cell then reassembled with new gas. Our experience is that if the cell doesn't produce a spontaneous voltage on the first assembly it will after the second or third attempt. The voltage is typically highest when the DVM is initially connected and then drops to a nearly steady value determined by the load presented by the DVM's input impedance. Over several days the voltage slowly may decline further. For the cell shown the voltage even declined to the point that the voltage changed polarity and the absolute value of the voltage started to increase. After several more days the voltage slowly returned to its initial polarity. We don't fully understand what is happening but one possibility is that the difference in work function between the inner Pd-H electrode and the outer electrode is slowly changing.

Extraordinary Claims Require Extraordinary Evidence

Another LEC cell producing spontaneous and self-sustained electrical energy for several months into a DVM with a 1 MΩ input impedance

This LEC cell has the same 1.1 mm electrode to electrode separation as the as the previous cell except that it has a galvanized nipple for the outer electrode. The work function for the galvanized pipe is essentially that for Zn. In subsequent test data, it will be observed that the work function for the Pd-H or Pd-D electrode may fall between the work functions of brass and zinc. Note that the load on this cell is 1 MΩ vice to 10 MΩ used in the previous slide. Data where the load resistance was varied from approximately 1 MΩ down to a few hundred ohms is presented later in this presentation. For these tests, a battery powered DVM was used in order to eliminate any possibility of an external source of energy or a sneak ground path. The DVM had an optical interface to a USB computer connection and a sample rate of approximately 2 samples per second was for our variable load experiments.

Example of LEC Cell Construction



LEC cell description:

1. ⅛ inch by 4 inch brass nipple with id threaded at one end with 5/16 – 24 tap and then codeposited with Pd-H or Pd-D
2. 5/16 x 24 set screw with Cu wire brazed on one end and screwed into threaded nipple
3. ⅜ inch by 5.5 inch brass or galvanized pipe nipple (provides different work functions between outer pipe and the inner brass nipple.)
4. ⅜ inch to ¼ inch bushings on each end of the ⅜ inch nipple
5. ¼ inch nipple and valve to evacuate and fill LEC with hydrogen or deuterium gas
6. ¼ inch nipple with high temperature epoxy fill to provide electrical insulation
7. Small high temperature O-rings or a bead of high temperature epoxy to maintain physical separation between items 1 and 3 while allowing gas to pass between. Note O-rings provide separation and do not seal the gas

In addition to the cell dimensions described in this slide, tests using a ¾ inch pipe nipple for the outer electrode have been used. A LEC device, in its simplest implementation, is a two terminal electrical device comprised of physically separated electrodes in fluidic contact with a gas comprised in part of hydrogen, deuterium or combinations thereof. The inner working electrode is comprised in part of a hydrogen host-material lattice such as nickel (Ni) or palladium (Pd) that forms an interstitial metal hydride with hydrogen. Thermal energy in the host-material's lattice interacts with the hydrogen atoms to produce ionizing radiation that ionizes the gas and results in a voltage between the electrodes and causes an electric current to flow through a load resistance connected between the electrodes. Several LEC designs have been constructed and tested including either hydrogen or deuterium gas, the use of different materials, changes to cell dimensions that increase or reduce the separation distance between the electrodes, and additional electrodes and electrode structures composed of materials such as copper and zinc which have different work functions to interact with the ions produced to develop a current or voltage. Furthermore, experimental evidence suggests that the production of ions and the conversion to electricity involves multiple physical phenomena such as the nonlinear lattice dynamics of different interstitial hydridable materials as a function of temperature and hydrogen loading, hydrogen gas pressures, and the separation distance between the electrodes. For example, experimental evidence indicates that the flux of ionizing radiation and the spontaneous electrical current and voltage produced increases approximately exponentially with the temperature of the working electrode over the range of temperatures tested to date and this increase is anticipated to continue for higher temperatures limited by the thermal and mechanical properties of the materials. For some embodiments, additional features may be included such as ports, valves, electrical feedthroughs, additional electrode structures and their placement relative to the working electrode, a heater or a source and means to transfer low grade or waste heat to the LEC, and a source of magnetic field. ("State-of-the-Art Technologies on Low-Grade Heat Recovery and Utilization in Industry" Ling-Chin et. al. 5 Nov, 2018, DOI: 10.5772/intechopen.78701)

Extraordinary Claims Require Extraordinary Evidence

Replication by Jean-Paul Biberian
November 2, 2020

Codeposited Pd with $PdBr_2$ and LiBr on a 2mm diameter 10cm long Pd/Ag electrode

LEC cell self-initiated and self sustained the production of 300 mV and then 500 mV

In this replication experiment by Jean-Paul Biberian an approximately 1 mm diameter $Pd_{1-x}Ag_x$ where $x \approx 0.25$ wire was used as the inner or working electrode. Hydrogen gas used and the cell was heated to several hundred degrees Celsius in order to increase diffusion of hydrogen into the metal lattice. Unfortunately, in this first attempt at replication no spontaneous conduction voltage was measured. However, after consultation with Dr. Frank Gordon, The $Pd_{1-x}Ag_x$ wire was electroplated with an additional Pd layer in order to ensure that there would be a larger number of vacancies in the Pd. It is suspected at this time that vacancies play an important role in Pd spontaneous conduction activity. The plating bath was an aqueous solution of $PdBr_2$ and LiBr of the same molarity as the $PdCl_2$ and LiCl baths used for the cells of two previous slides. This time the completed LEC cell generated an initial voltage of 300 mV that increased to 500 mV after some alcohol was used to check for a possible leak.

Recent Replication Results by Jean-Paul Biberian
12 January 2021

Cell Construction: Two concentric cylinders approx 10cm in length and the outer cylinder was a silver foil 6cm in diameter. The inner cylinder was stainless steel, approximately 5.6 cm in diameter resulting in a 2mm gap between the cylinders. Palladium was codeposited on the inner surface of the outer diameter cylinder. When a vacuum was pulled on the cell, no voltage was measured. He filled the cell with hydrogen gas and it produced 540mV. After several hours, the voltage had risen to 740 mV. He conducted a load test with the following results:

Resistance Ω	Voltage (Volts)
10M	.740
1.5M	.734
150k	.640
56k	.500
1k	.05

Extraordinary Claims Require Extraordinary Evidence

Replication by Andrew Erickson
Senior Leader at Los Alamos National Laboratory

Replicated on 11/23/2020

Mylar window to provide access for sensors to identify the ionizing radiation.

LEC cell produced 0.115 V into a 5 MΩ load with air!
Increased to .170 V when hot air was blown into the cell

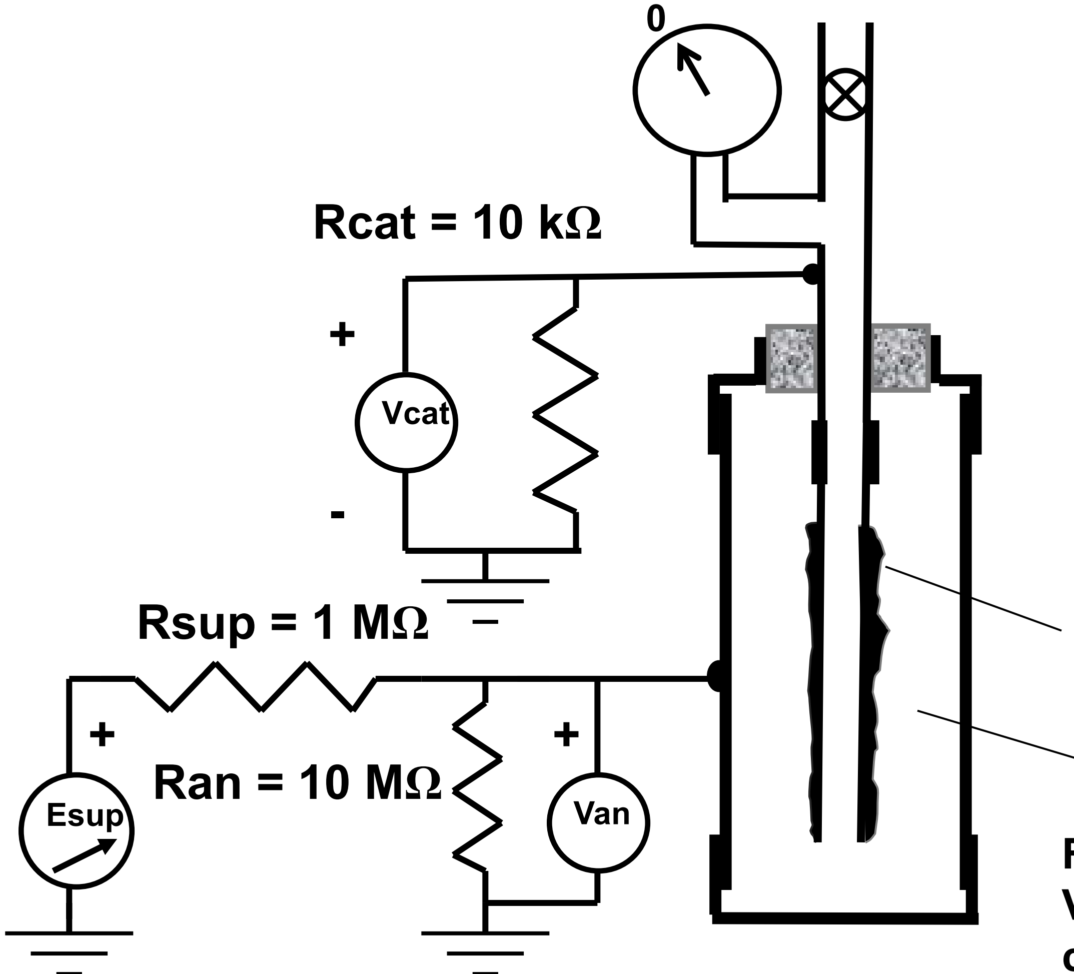
Future Replications

- We are collaborating with the Indian Institute of Technology, Kanpur (IIT-K) to conduct replications with additional instrumentation when access to the campus (and graduate students) is allowed.
- My grandson (8th grade) was planning a replication as his science fair project but the science fair was cancelled due to COVID. Maybe next year.

Pathway to a LEC

- In 1866 Graham showed that Pd metal occludes H_2
- In 1896 Thomson and Rutherford showed that the conduction of electricity in a gas is due to ions
- In 1928 Kramer showed that ionized gas between electrodes of dissimilar work functions produces a voltage and a current through an attached resistance
- In 1989 Pons and Fleishman showed that D_2 in Pd releases energy during electrolysis
- LENR scientists report that output increases approximately exponentially with temperature
- Papers in the LENR-CANR library by Rout, Srinivasan, and others in the early 1990's reporting that ionizing radiation was produced

Our Pathway to a LEC started with high temperature gas electrolysis



-5 psig ≥ *P*cell ≥ 30 psig

-55 °C ≥ *T*cell ≥ 30 °C

0 V ≥ *E*supply ≥ 1000 V

*V*cell = *V*an - *V*cat

*I*cell = *V*cat / 10 kΩ

For these experiments, Vcat and Van were measured by LabJack channels with a TIC to provide very high impedance

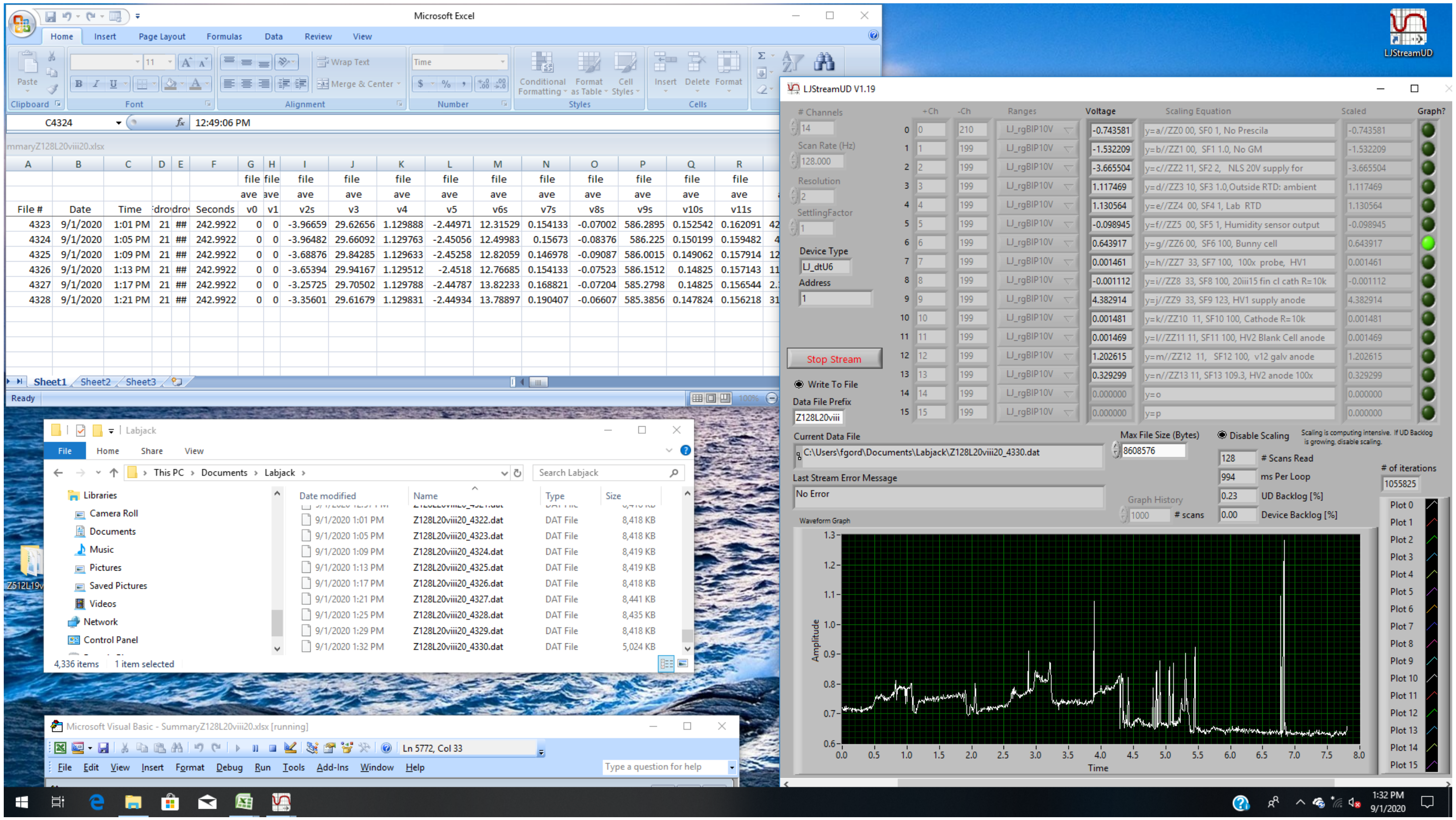
Multiple cells have been constructed and tested. The inner electrode has been prepared using ¼ inch Copper tubing and ⅛ inch brass nipples that have been codeposited with Pd-D or Pd-H for approximately 3.5 inches or 7.6 cm. A ¾ inch or a ⅜ inch brass or galvanized pipe nipple has been used for the outer electrode. Depending on the combinations used, the separation distance between the inner and outer electrode has ranges from a little over 1 mm to about 6.35 mm. A nylon or PTFE bushing provides gas tight electrical isolation between the inner and outer electrodes.

A LabJack U6 Pro provides up to 14 channels of data recording at sample rates up to 1000 S/s. Prior to the Covid pandemic, a sample rate of 512 S/s was typically used which produced a 8.4 MB file of data about once each minute. Due to limited access to the laboratory during the pandemic, the sample rate was reduced to 128 S/s so longer unattended data collection was possible. In order to minimize the impact of the data system on the voltages being measured, several channels were installed with Labjack TIC's which greatly increased the impedance.

A Hewlett Packard DC power supply provides variable voltage up to 1000 volts and a current up to 6 mA.

Print Screen Showing Spikes

Typical sample rate of 512 samples per second



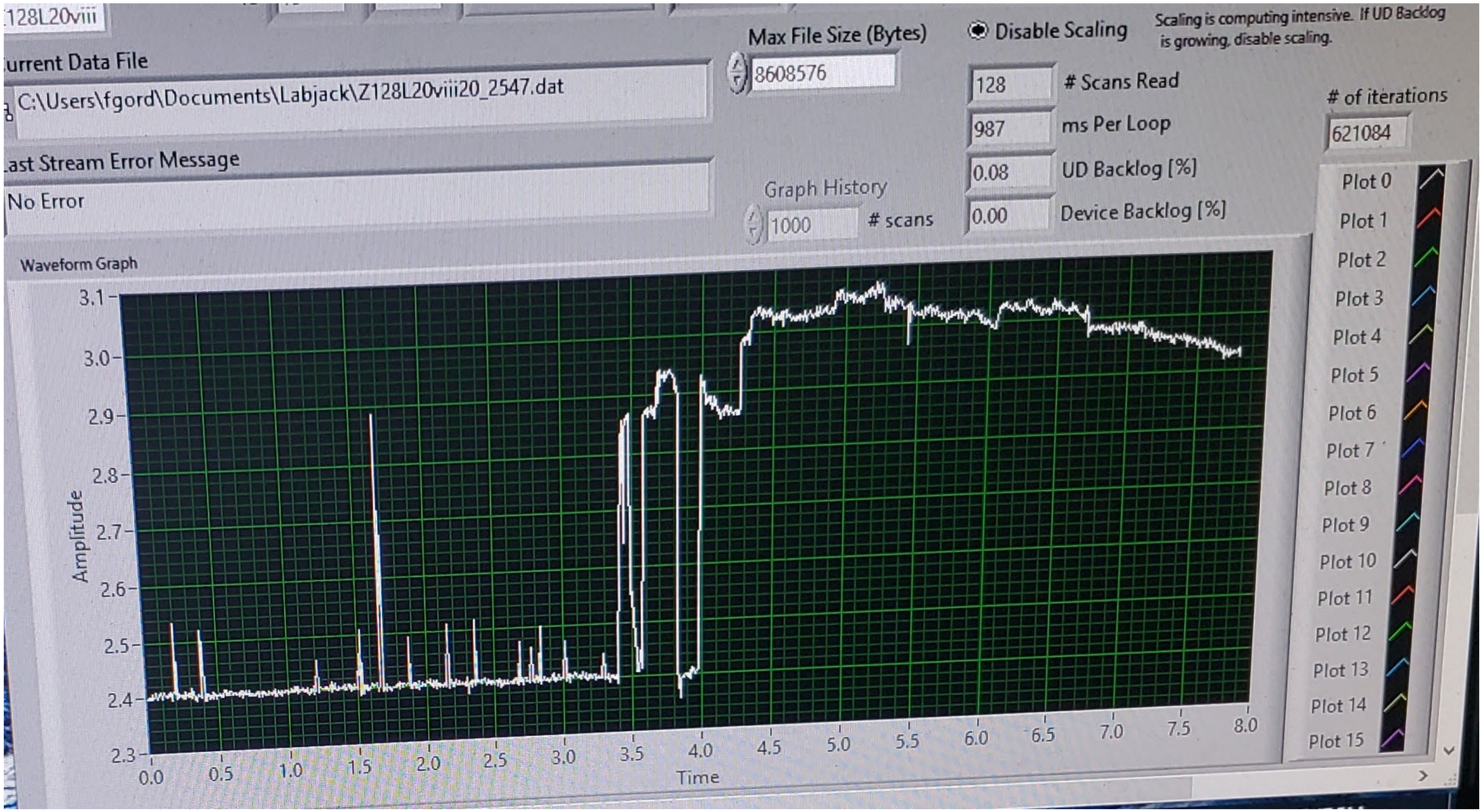
LabJack records up to 14 channels of data at sample rates up to 1000 S/s which is analyzed within one to four minutes depending on sample rate

This print screen displays the LabJack U6 Pro 14 channel data acquisition system along with processed data and file storage status. The Pd codeposited cathode as shown in the previous slide is displayed and the sample rate during this test was 128 samples per second. Multiple channels can be displayed simultaneously. The sample rate of 512 S/s has been typically used but it was reduced to 128 S/s during the Covid virus so that data acquisition could run longer without requiring human interaction. Even at 128 S/s, this visual display of spikes and jumps clearly shows properties that are not detected in liquid electrolyte systems that use calorimeters that may a integrate over several minutes.

The raw data is stored in files that typically have less than 32,000 rows of data to facilitate processing using Microsoft Excel with custom software written in Visual Basic. The individual files are processed as soon as they are complete. Basic processing includes applying the scale factor for each data point in the data channel, calculating the file average for each channel of data, the one second averages for each channel of data, and the maximum and minimum data points per file and per second. Depending on the test, statistical analysis such as standard deviation, Fourier analysis, neutron detection and gamma detection and spectrometry, calculations of ionization rates, cell currents and power, etc. have also been included in the processing that is completed before the next complete the file is available.

Photograph Showing Spikes

and voltage jumps recorded at a sample rate of 128 Samples per second



Voltage spikes and jumps are not observed by calorimeters that may average over several minutes

This photograph shows 8 seconds of data being continuously scrolled across the screen and sampled at 128 S/s. Both spikes and a jump in cell output have been observed many times. By using two of the LabJack channels to record cell temperature and ambient temperature, it's possible to correlate cell output as a function of temperature.

Tests conducted several years ago using both neutron and NaI gamma detectors did not show a correlation between the detection of a gamma or neutron and the spikes or cell output. Peter Hagelstein presented a paper at ICCF 21 in 2018 in which his theory included the production of 14.4 keV gamma. We provided him data from tests we had conducted in 2013 that indicated a gamma signature in that energy range. Lead shielding was positioned around our cell to reduce/prevent background radiation and a signal level of approximately 12 detections per minute was measured. This level was clearly above background and above control testing and it did not correlate with spikes in other data channels.

A Surprising Discovery

- In experiments to see if 6 µCi of Am-241 was sufficient to ionize a gas to load hydrogen into a Pd lattice and retain it using fugacity, we realized that the current conducting in the cell was several orders of magnitude greater than expected from the Am-241
- No conduction was observed when the Pd-H electrode was removed leaving only the 6 µCi Am-241 sources, i.e, it was below the sensitivity of our instrumentation
- When the Am-241 was removed, the cell conducted with only the Pd-H

Conclusion: The Pd-H was ionizing the gas!

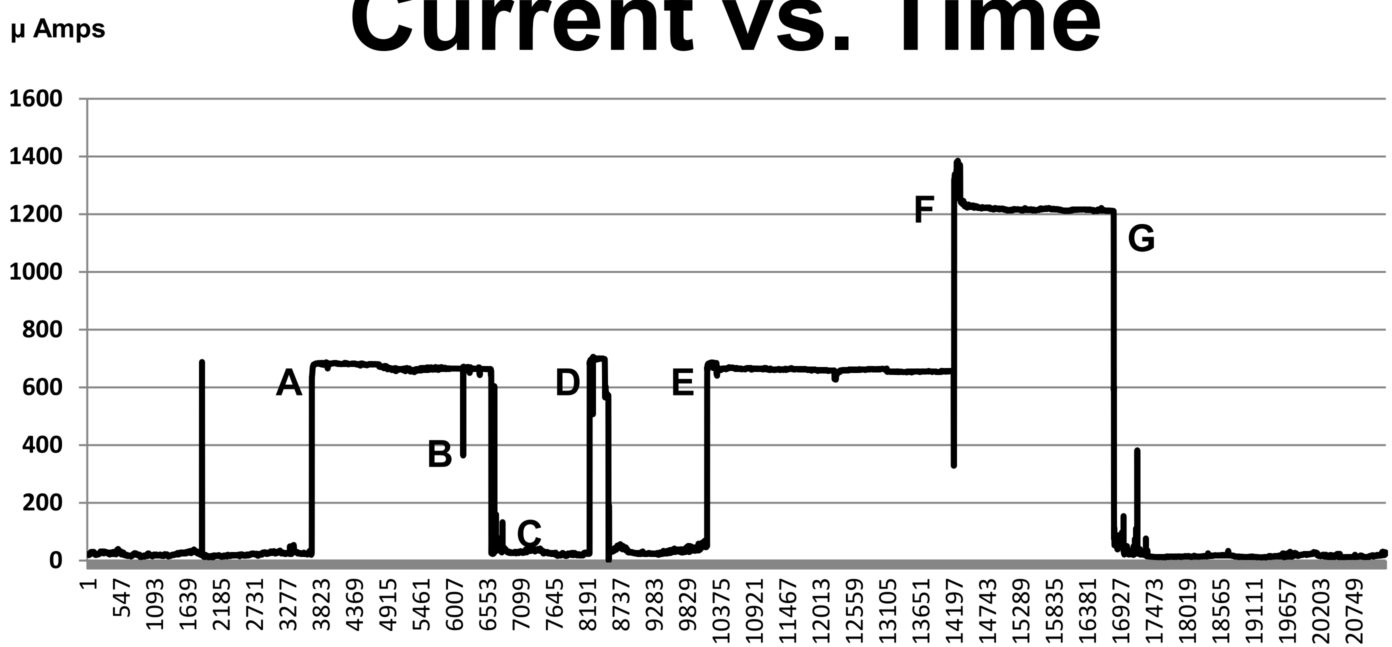
While conducting experiments to see if we could ionize a gas using 6 μCi of Am-241 to load hydrogen into a Pd lattice and retain it using fugacity, we realized that the amount of current that we were conducting was several orders of magnitude greater than expected from the Am-241

The current conducted during tests using the Am-241 but with a working electrode that was not codeposited with Pd-H was below the sensitivity of our instrumentation

Stimulation of ionization with radiation was not required since tests without the Am-241 conducted!

Conclusion: The Pd-H was ionizing the gas!

Current vs. Time



Files (each file approx 61 seconds at a sample rate of 512 samples per second)
Total time: Approximately 14.5 days

During periods A, D, and E, the cell was conducting at the maximum allowed by the 1 MΩ current limiting resistor
At F, the current limiting resistor was changed to allow twice the current to flow
At G, the current limiting resistor was further changed to allow more current to flow and the current went up for a few milliseconds and then dropped
At point B, a variable voltage test was conducted

Each file is approximately 61 seconds at a sample rate of 512 samples per second. The total time shown is approximately 14.5 days.

During periods A, D, and E, the cell was conducting at the maximum allowed by the current limiting resistor

At F, the current limiting resistor was changed to allow twice the current to flow

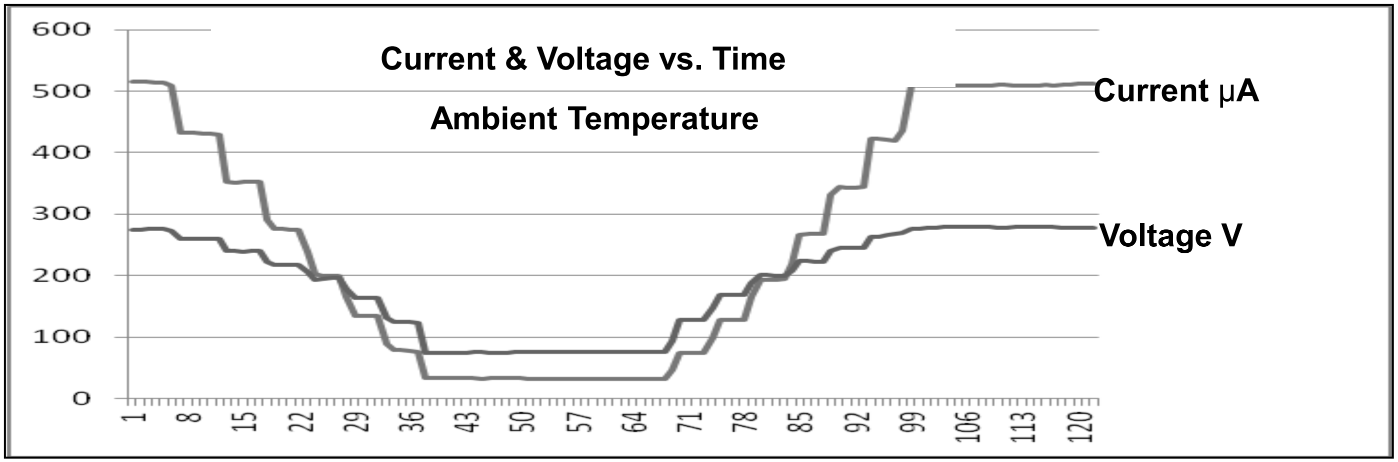
At G, the current limiting resistor was further changed to allow more current to flow and the current went up for a few milliseconds and then dropped

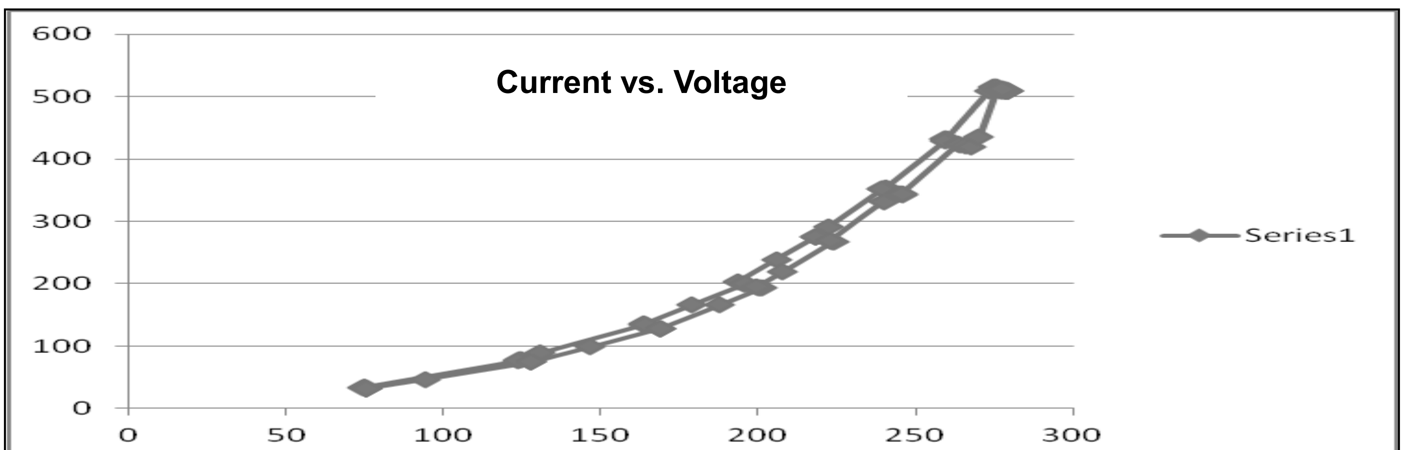
At point B, a variable voltage conductance test was conducted

Variable Cell Voltage and Current

Current [μA] and Voltage [V]

Example of Voltage Controlled Production of Ionization

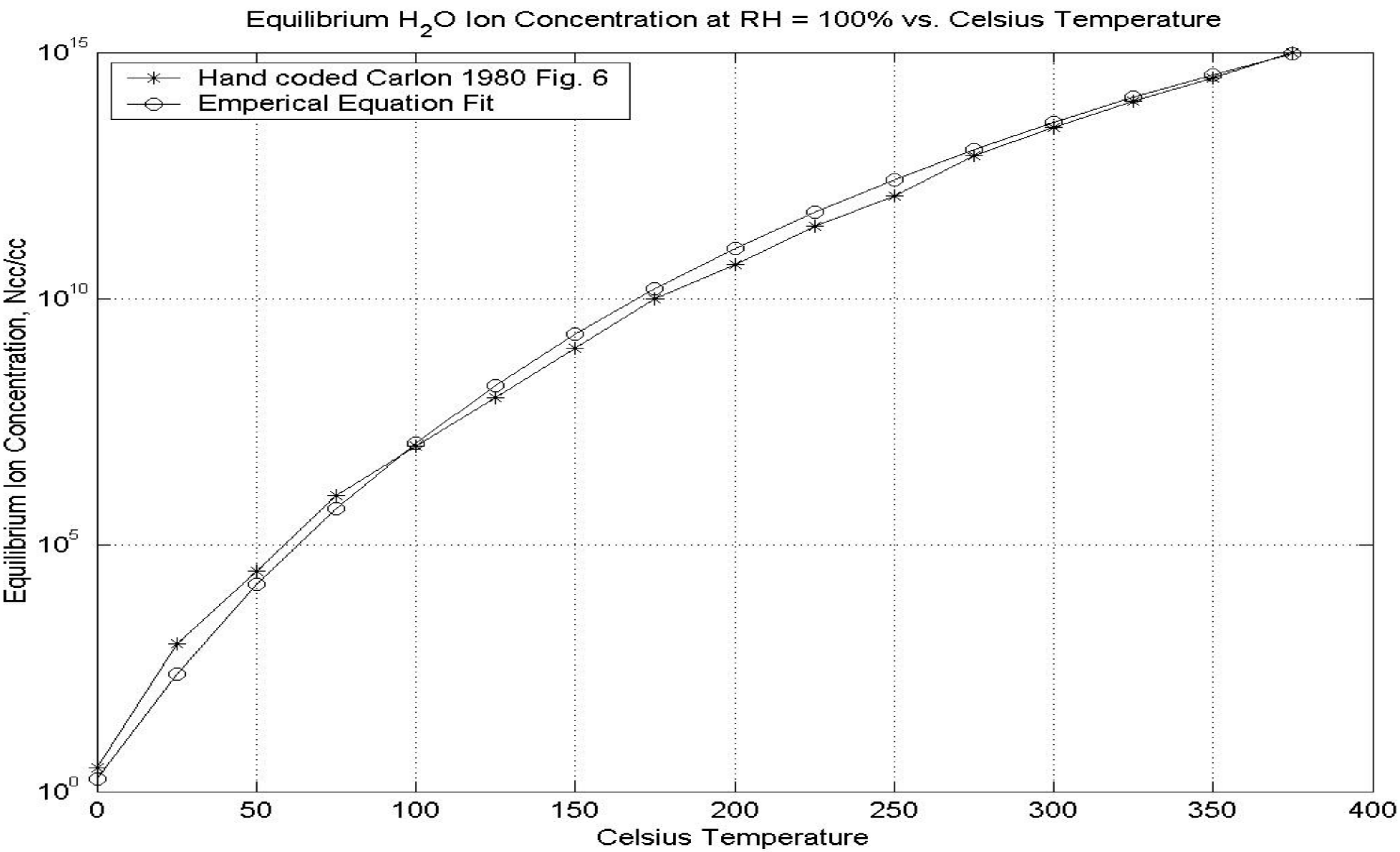




The gas used in the InovL experimental cells is prepared by reacting either H_2O or D_2O with lithium (Li) metal recovered from Lithium Batteries.

Although dry gas is not a conductor of electricity, ionized water vapor is a conductor. However, even if the relative humidity (RH) is 100%, the conduction due to water vapor is at least 3 orders of magnitude lower than the measured conductivity. Equilibrium water ion concentration at a relative humidity (RH) of 100 % vs. T in °C is shown below along with an empirical exponential fit.

H_2O Ion Concentration at RH = 100 %

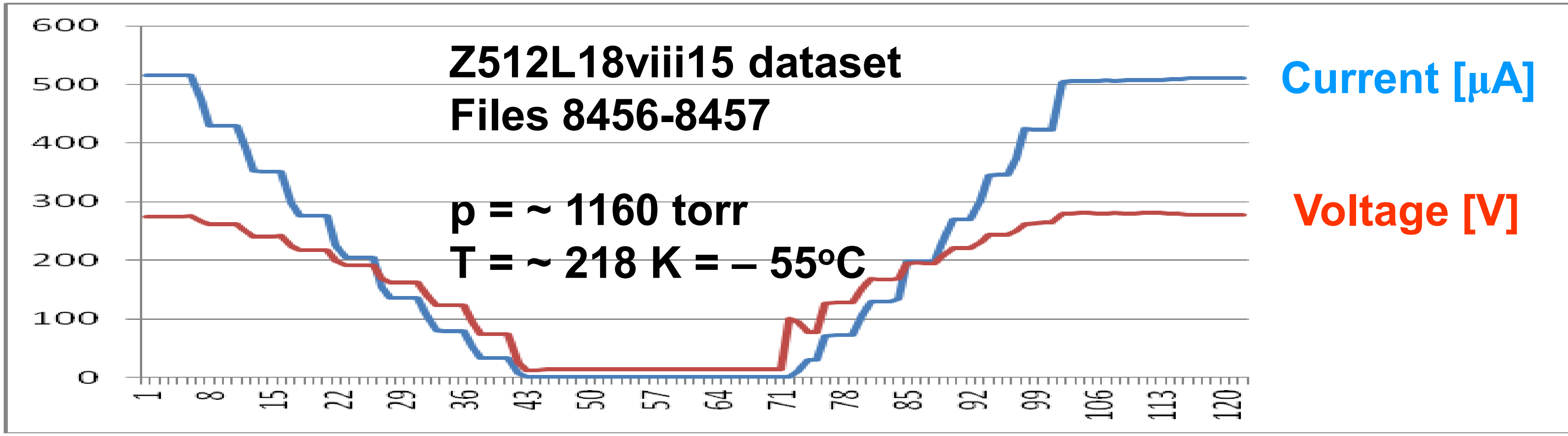


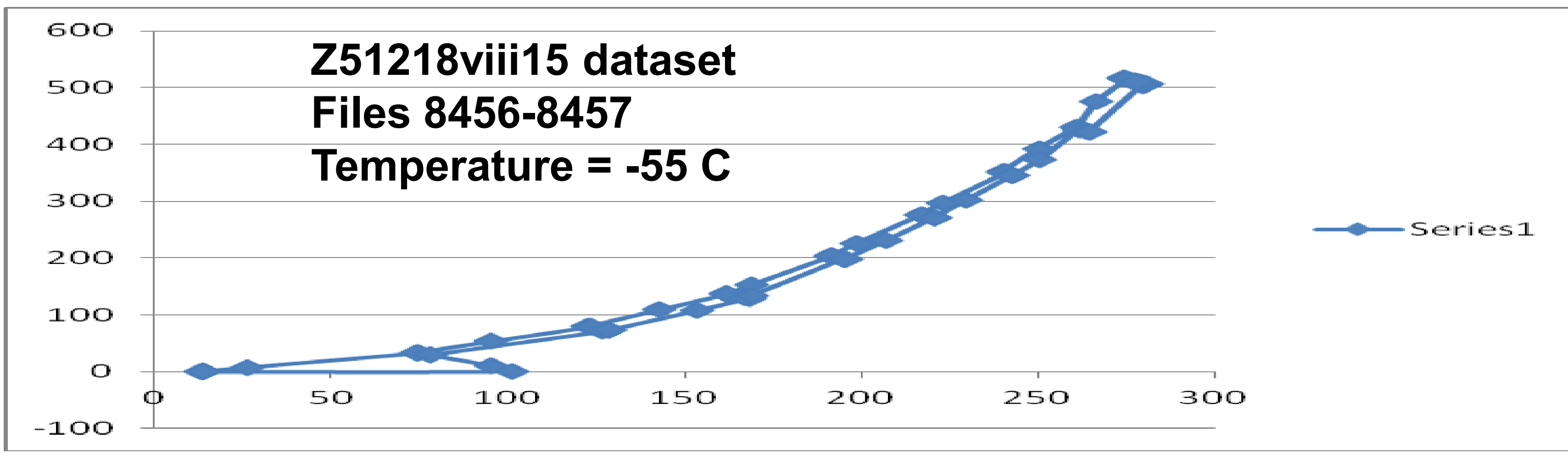
The upper figure shows fast voltage steps with time measured in seconds. Time was short in order to minimize deuterium out gassing on the voltage down-steps and to minimize deuterium loading on the voltage up-steps after recovery of conduction current started.

The lower figure shows an I-V curve of current versus cell voltage.

Current [μA] & Voltage [V] vs. Time [s] Cell

Cold to Exclude D_2O Vapor Effects



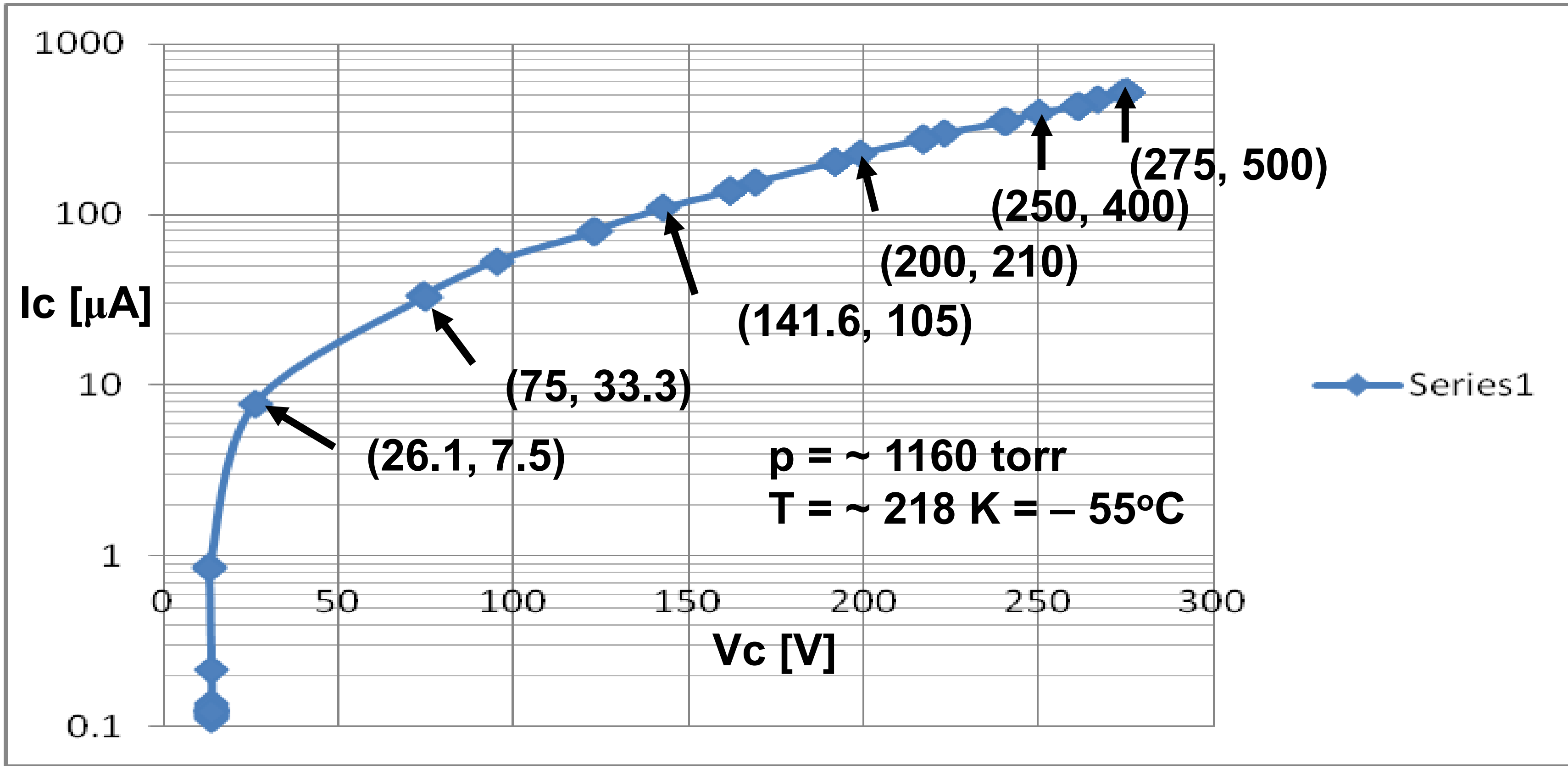


This test was conducted at -55°C in order to freeze out and eliminate conduction due to water vapor. The upper figure shows fast voltage steps with time measured in seconds. Time was short in order to minimize deuterium out gassing on the voltage down-steps and to minimize deuterium loading on the voltage up-steps after recovery of conduction current started.

The lower figure shows an I-V curve of current versus cell voltage.

Note that the conduction is essentially the same as the previous room temperature test thus establishing that water vapor is not the cause of the cell's conduction.

Cell Current [µA] vs. Voltage [V]
Preliminary Data Analysis

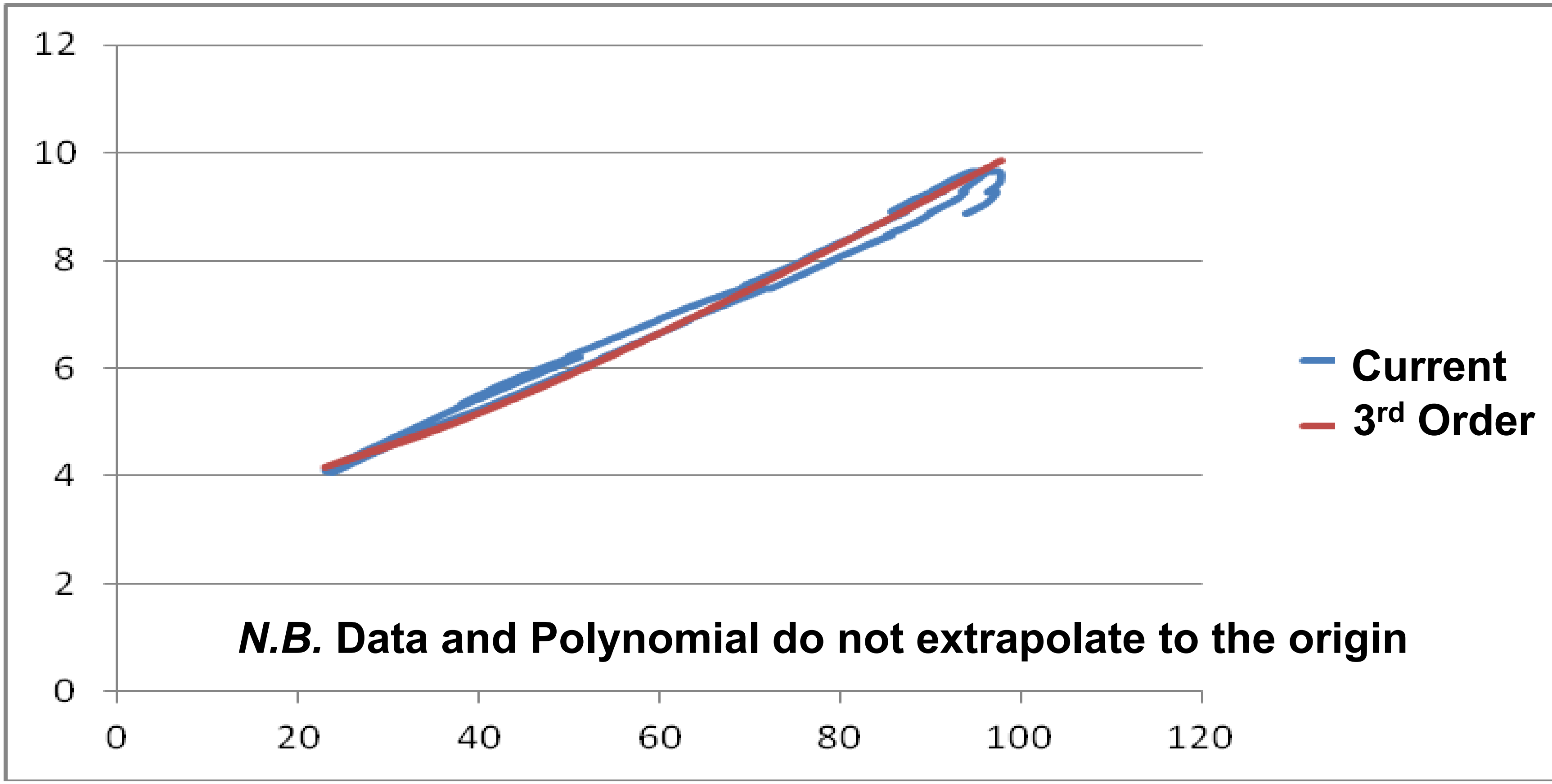


Fast voltage steps **with time measured in seconds. Deuterium out gassing minimized on voltage down-steps. Fast fugacity deuterium loading is observed on voltage up-steps after recovery of conduction current**

Preliminary analysis leads one to believe that the cell current is approximately exponential down to lower voltages when the current appears to drop on the simi-log scale. However, further analysis of this experiment and subsequent tests shows that the drop in current at low voltages is a very important feature of this test. Based on further analysis and additional test results, this drop in current is attributed to a spontaneously generated cell current that is opposite the injected current.

LEC Discovery Analysis

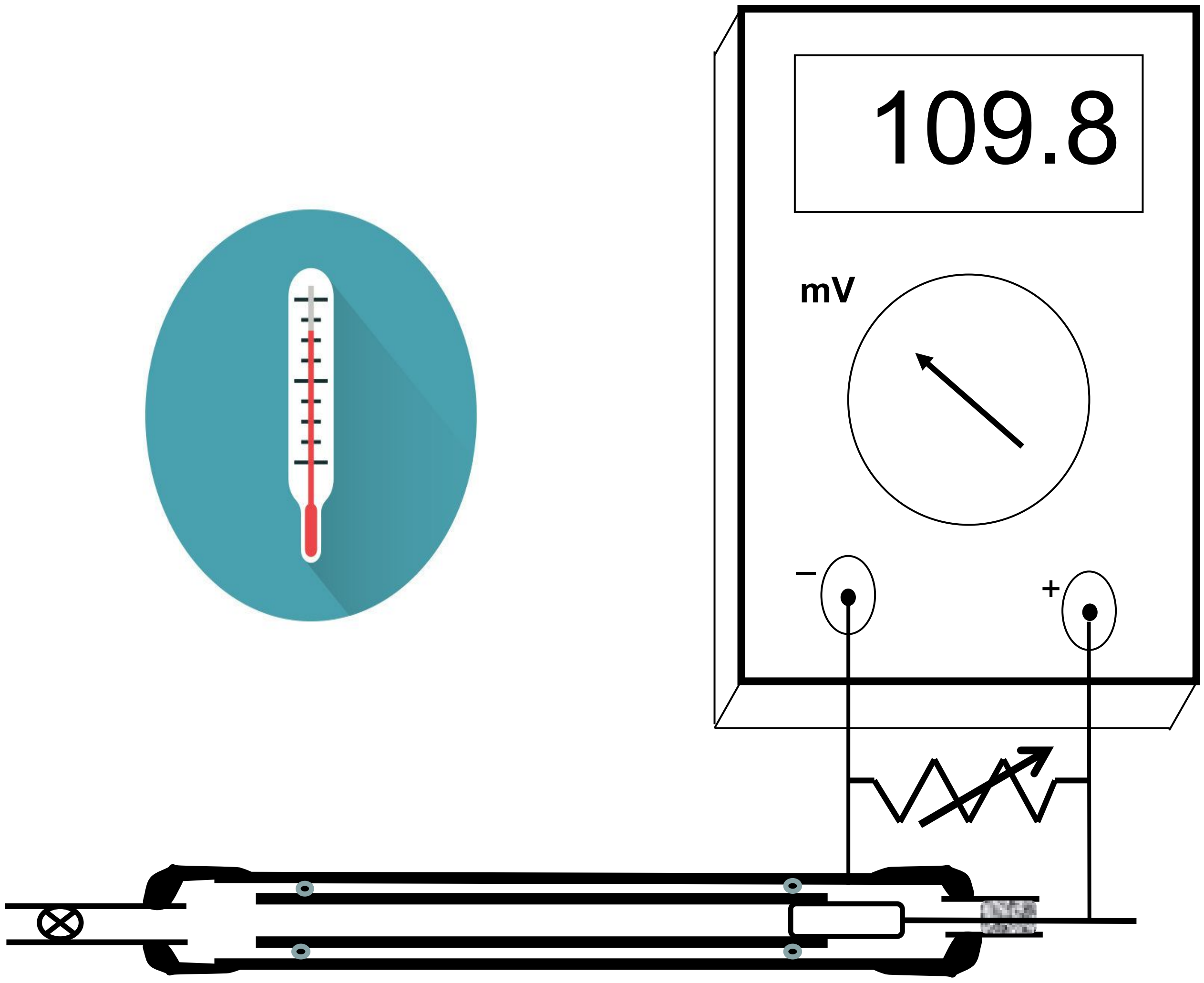
Cube Root of Current and Cube Root of 3rd Order Polynomial Equation vs. Voltage



N.B. **Data and Polynomial do not extrapolate to the origin**

The most important observation from these results is that the two curves do not extrapolate to the origin for the externally supplied cell voltage to be zero. This observation is easily tested by removing the external voltage supply and measuring the cell voltage with a DVM. In this measurement there was a spontaneous and self-sustaining positive cell potential and thus a spontaneous current flowing through the DVM's input impedance of ~10 MΩ. This spontaneous current flowed in the opposite direction of the current that was induced by the externally applied voltage to the cell that was used to measure cell conductance.

Instrumentation Required



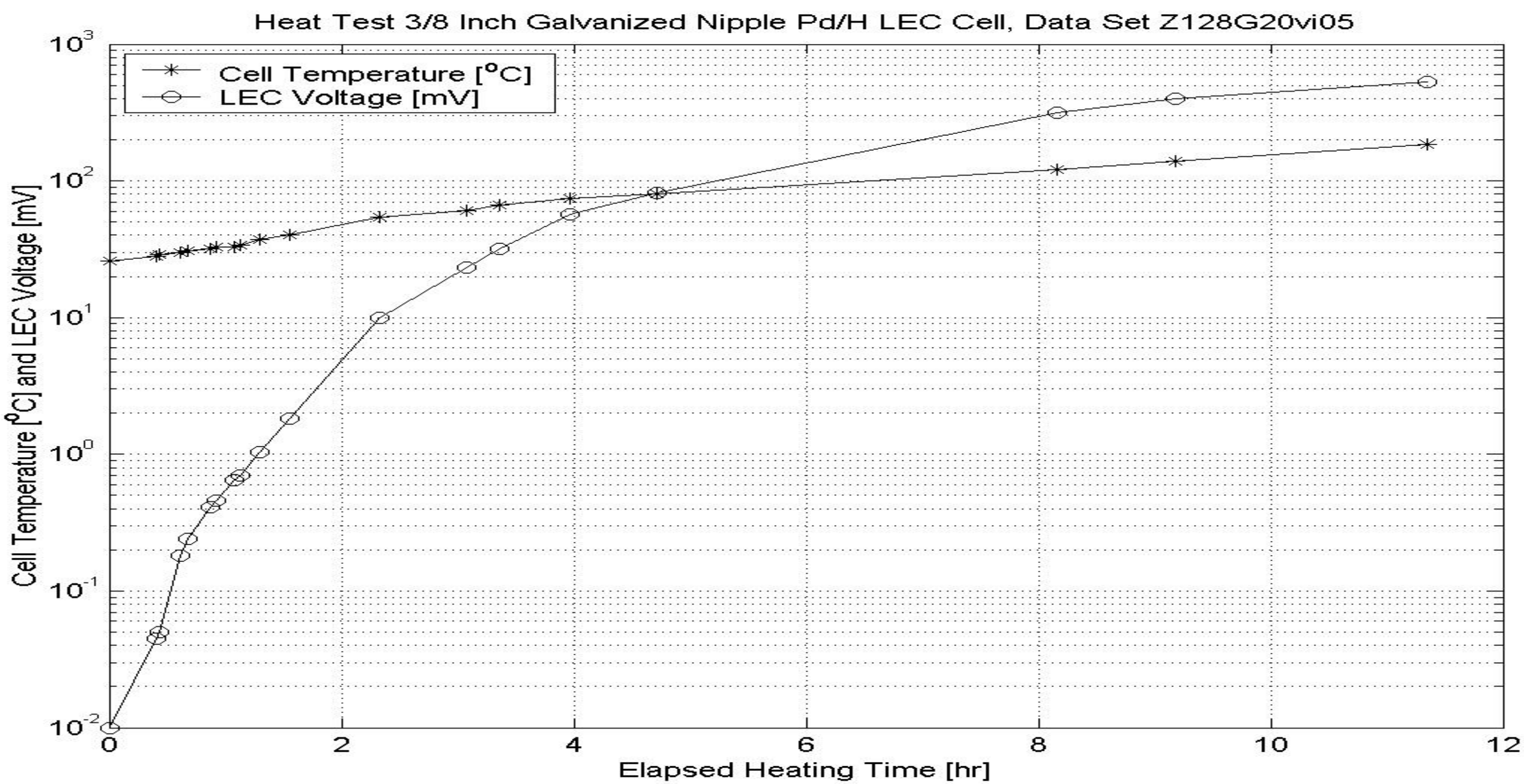
Characterizing a LEC

- Measure the spontaneous LEC voltage across a load resistance as a function of time and temperature
- At selected temperatures vary the load resistance and calculate the current versus resistance
- Postulate physical and electrical processes that could produce the experimentally measured values
  - Lattice vacancies as a function of temperature
  - Conduction of electricity through a gas as a function of the electric field strength in the gas
- Construct a phenomenological equivalent circuit
- Refine the equivalent circuit using different LEC configurations and different measurement techniques
- Refine the LEC design to optimize and scale up

Designs and Tests Preformed

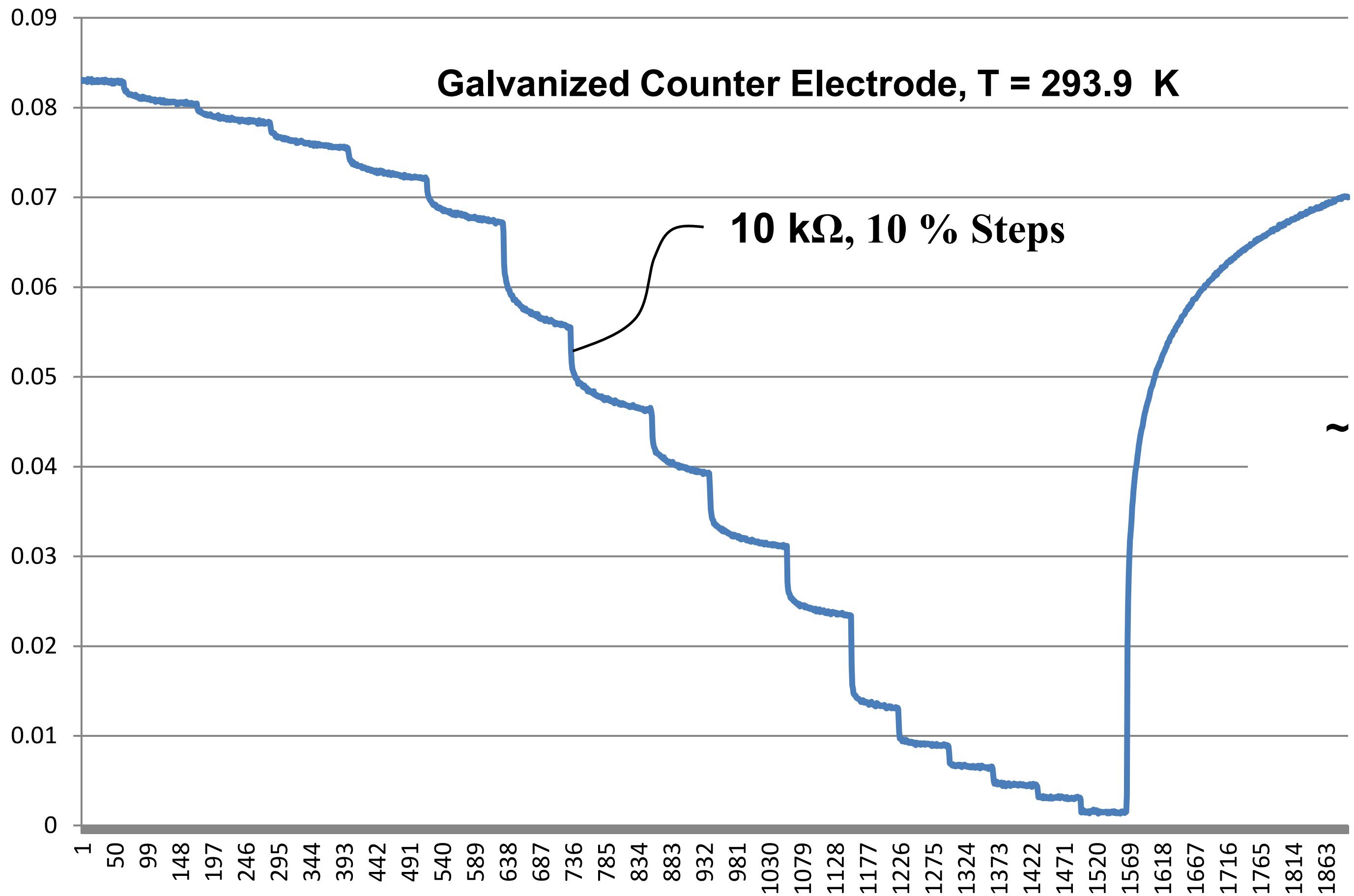
- **Over 100 different LEC's have been tested**
- **Cylindrical air filled open cell: LEC voltage vs. time**
- **Cylindrical H_2 or D_2 filled closed cells with ~1.1 and ~6 mm electrode separations**
  - **LEC voltage vs. temperature at fixed load resistance**
  - **LEC voltage vs. variable load resistance at fixed temperature**
  - **Cell current and impressed voltage vs. time at variable temperature**
- **Cylindrical H_2 filled closed cell with split counter electrode (CE)**
  - **LEC voltages between split CE and working electrode vs. time.**
- **Cylindrical D_2 filled closed cell with a radial electrode structure of Cu and Zn fins with separation distances up to 4 cm**
  - **LEC voltage between Pd and fins as well as between Cu and Zn**

Pd/H LEC Temperature and Voltage
versus Time in Hours



LEC Cell Voltage vs. Load Resistance

Plots the LEC voltage vs. time for different external load conditions.



~ 12 Second Steps
26 May 2020

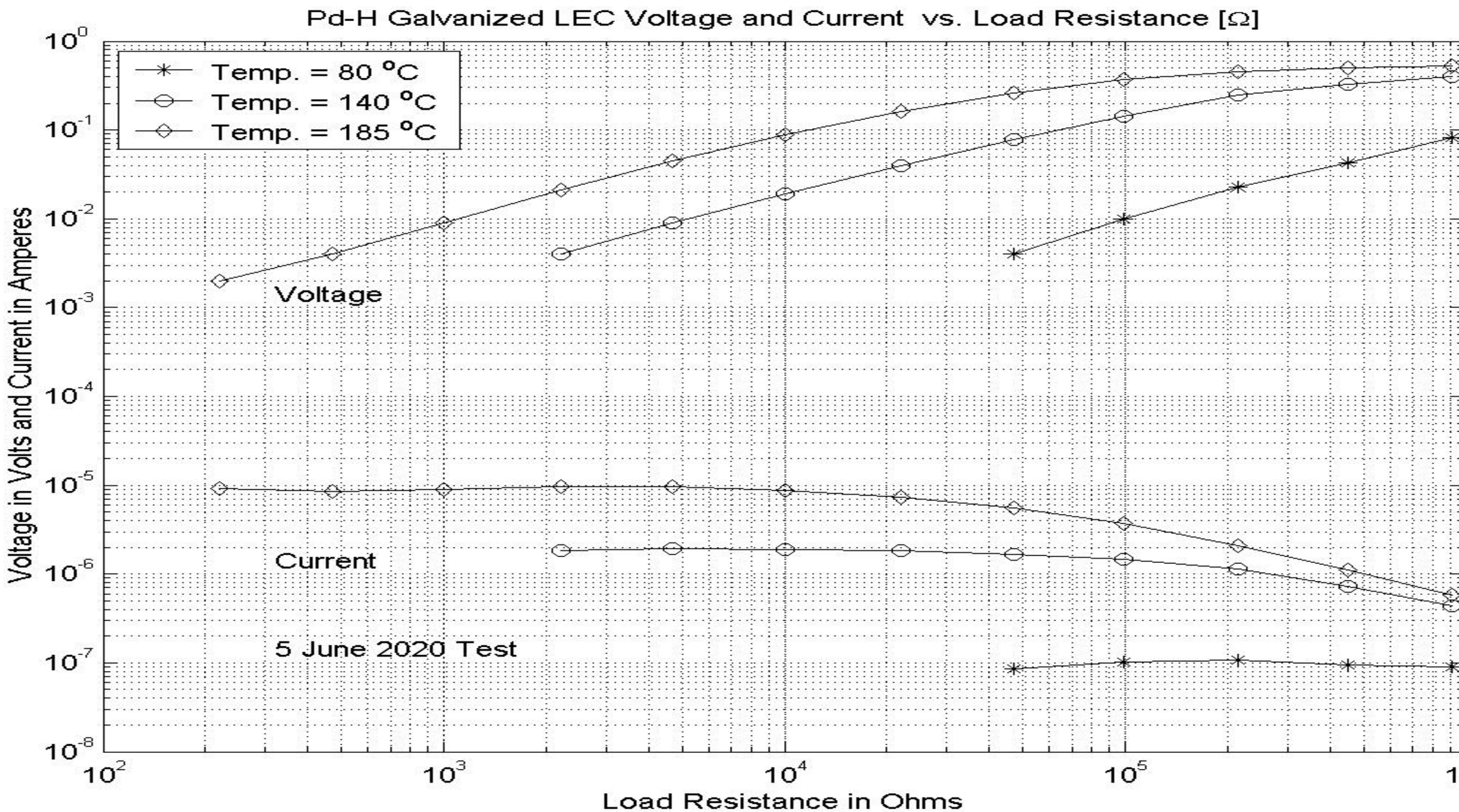
128 Samples/s

In order to understand the electrical characteristics of a LEC device cell current versus voltage (I-V) under load measurements can be made. A LEC is a spontaneously conducting two-terminal device thus measuring the voltage (V) under a variable load impedance (Z) can be used to characterize its electrical properties. Since the average LEC voltage is a slowly varying function of time the variable impedance (Z) can be simplified to a variable resistance (R).

This slide plots the measured spontaneous voltage developed by a LEC cell with codeposited palladium (Pd) over a nickel (Ni) coated working electrode and a zinc (Zn) galvanized counter electrode in a deuterium gas environment. Twenty-one decreasing load resistors starting at 1 MΩ were applied for approximately 12 seconds each. The LEC cell was operating at a laboratory temperature of approximately 294 K or 20.7°C with no energy input other than the thermal energy in lattice dynamics due to the operating temperature.

Spontaneous LEC Voltage and Current vs. Resistance at 3 Temperatures

N.B. **Thermal energy, *i.e.,* heat, is the only input since the cell is in a kiln**

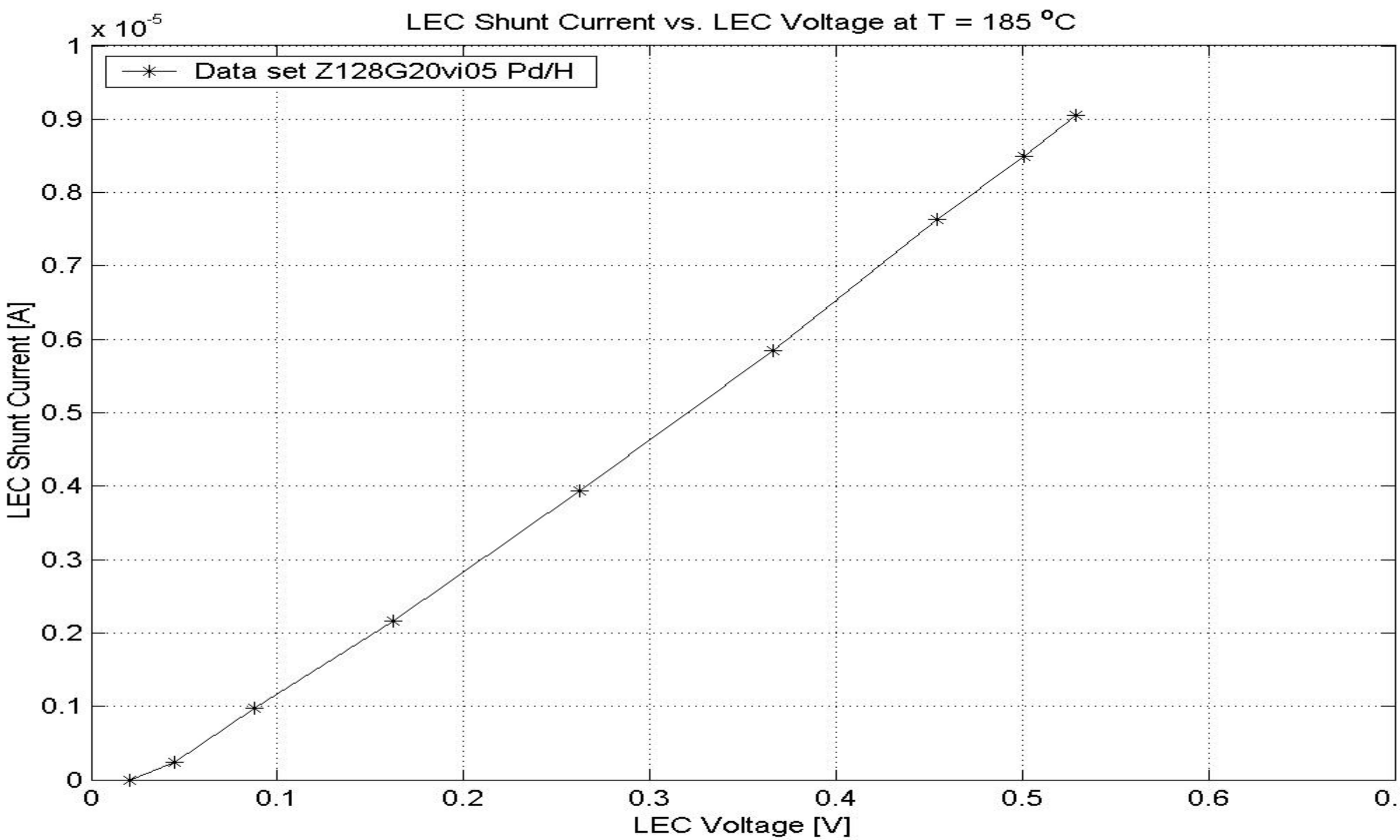


An inner to outer electrode distance of about 1.1 mm has been tested using a ⅜ inch galvanized pipe nipple outer electrode and palladium electrodeposited over a nickel (Ni) flash from a light water aqueous $PdCl_2$ and LiCl solution on a ¼ inch brass pipe nipple inner electrode. High temperature epoxy has been used to provide a pressure seal and to electrically insulate the inner and outer electrodes from each other.

The spontaneous conduction of the cell is allowed to stabilize before a load resistance test is started. Voltage across the load resistor is measured using an optically coupled recording digital voltmeter (DVM) with a sample rate of ~2 samples per second (S/s). During a resistance load test the resistance is held constant for only about 12 seconds in order to minimize outgassing (during down resistance steps) or gas loading (during up resistance steps) of the palladium (Pd). Current is calculated using Ohm's law.

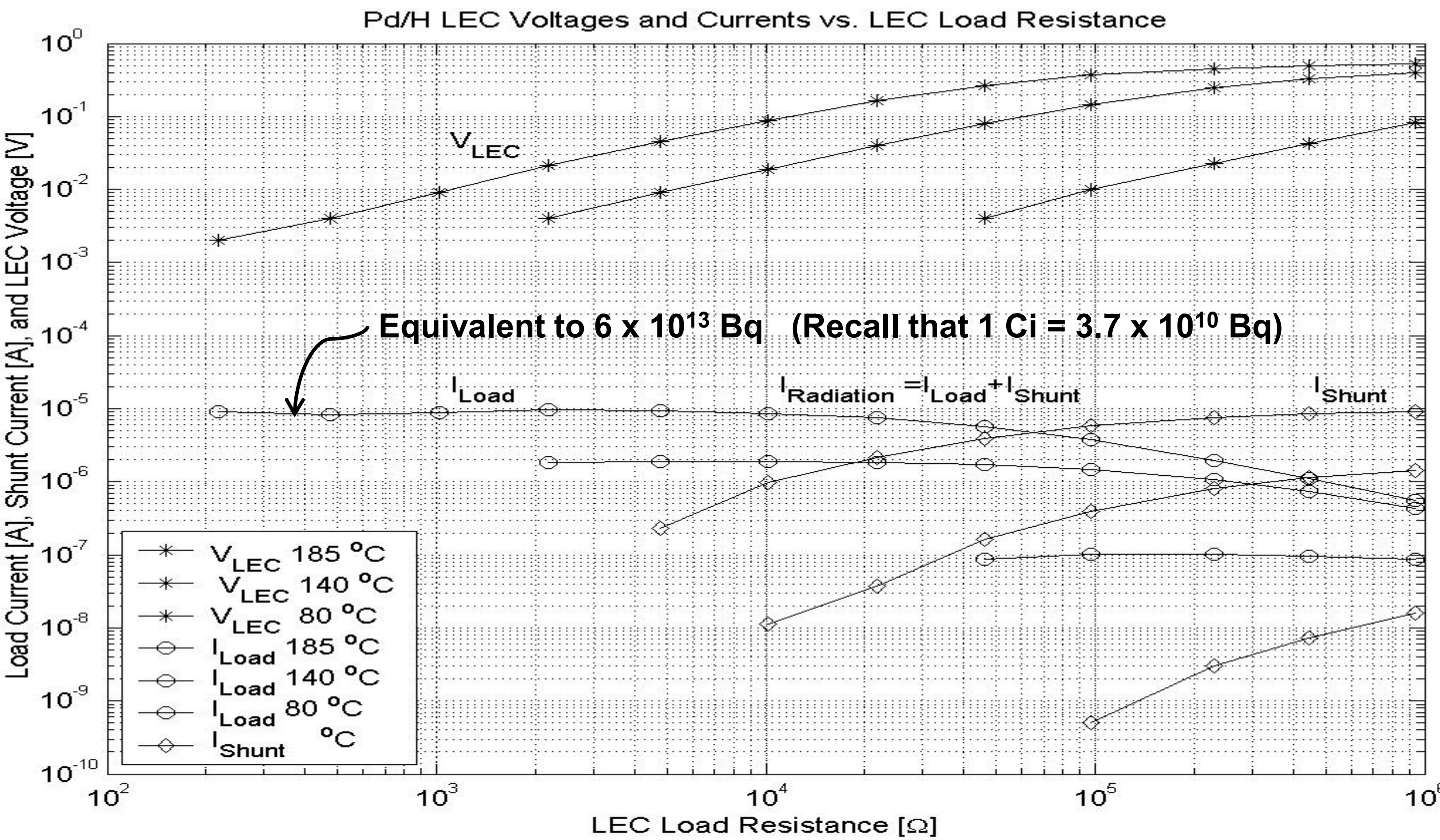
Observation of the voltage curves indicate that the current is essentially constant for low values of resistance. At 185°C the current is ~10 μA and this corresponds to a single charge carrying particle flux of $\sim 6 \times 10^{13}$ Bq or $\sim 2 \times 10^{3}$ Ci! The reduction of current at high values of resistance is attributive to an internal shunt conductance due to gas ions drifting under the influence of the electric field strength due to the voltage developed across the load resistance. As the flux of current due to the charged particles emitted from the working electrode transits the gas they ionize the gas on their way to the counter electrode losing ~35 eV for each ion-electron pair produced in the gas. These ions constitute the shunt current.

Missing Load Current vs. Voltage
T = 185 °C



Radiation Current Independent of Load

$$I_{Radiation} = I_{Load} + I_{Shunt}$$



Interpretation of Voltage vs. Resistance

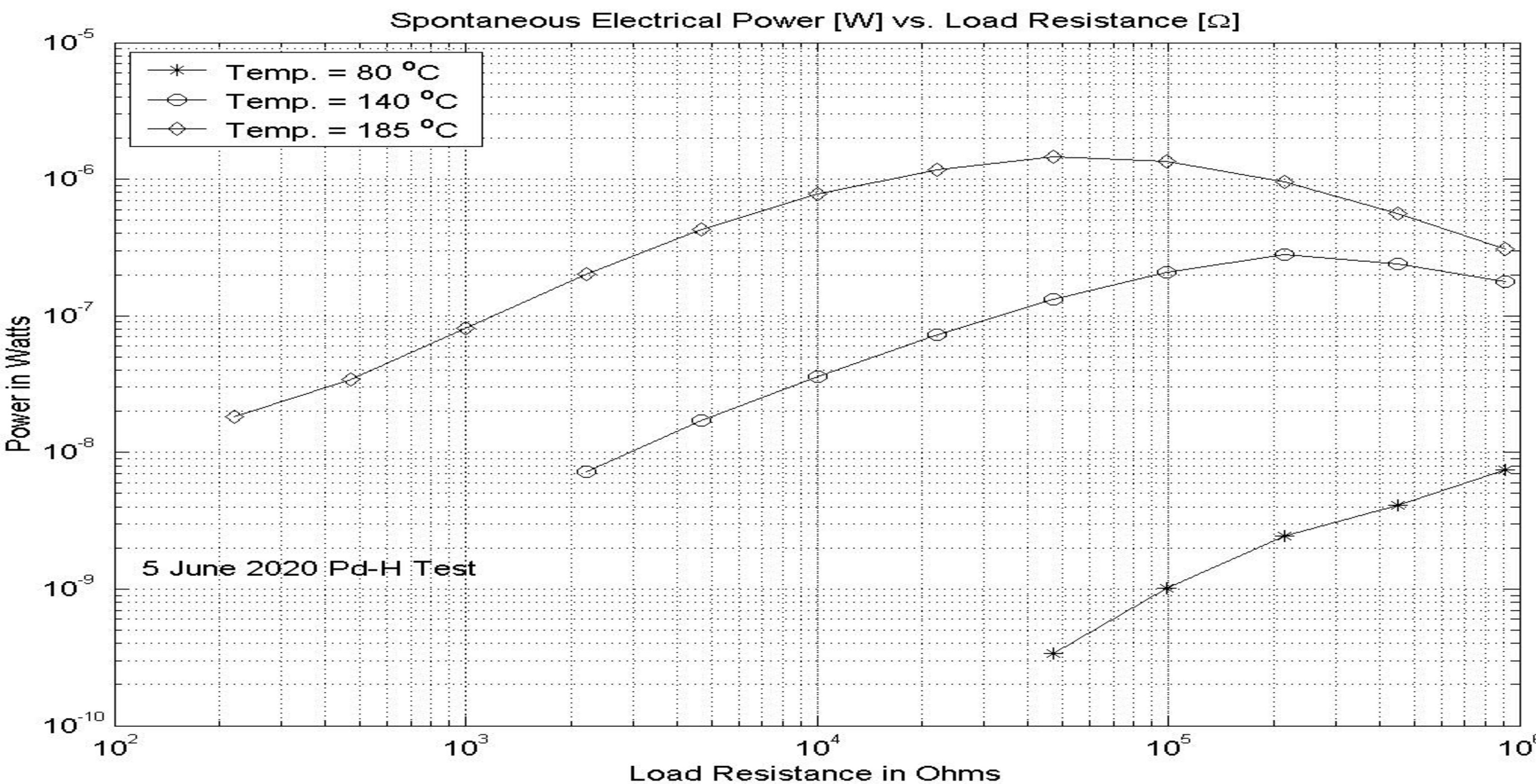
Load Current = LEC Voltage/Load Resistance

- **Low values of resistance and LEC voltage**
  - Load current, I_{Load}, independent of resistance
  - Characteristic of a current source, $I_{radiation}$
- **Higher values of resistance and LEC voltage**
  - Missing load current, $I_{Radiation} - I_{Load}$, linear in LEC voltage
  - Characteristic of a shunt current, I_{Shunt}, load conductance
- **Interpretation hypotheses**
  - Current source, $I_{Radiation}$, due to particulate ionizing radiation
  - Shunt current, I_{Shunt}, due to ionized gas between electrode
    - Thomson and Rutherford, 1896, predict that the conduction of ionized gas should be linear in the voltage for low voltages
    - Thomson, 1899, derives $V = \mathrm{A}i^2 + \mathrm{B}i$ where i is current density

Spontaneous Power vs. Resistance

Codeposited Pd and H_2 Gas at 80°C, 140°C, and 185°C

~300 nW at 140°C and 220 kΩ, ~1.5 µW Ω at 185°C and 47 kΩ

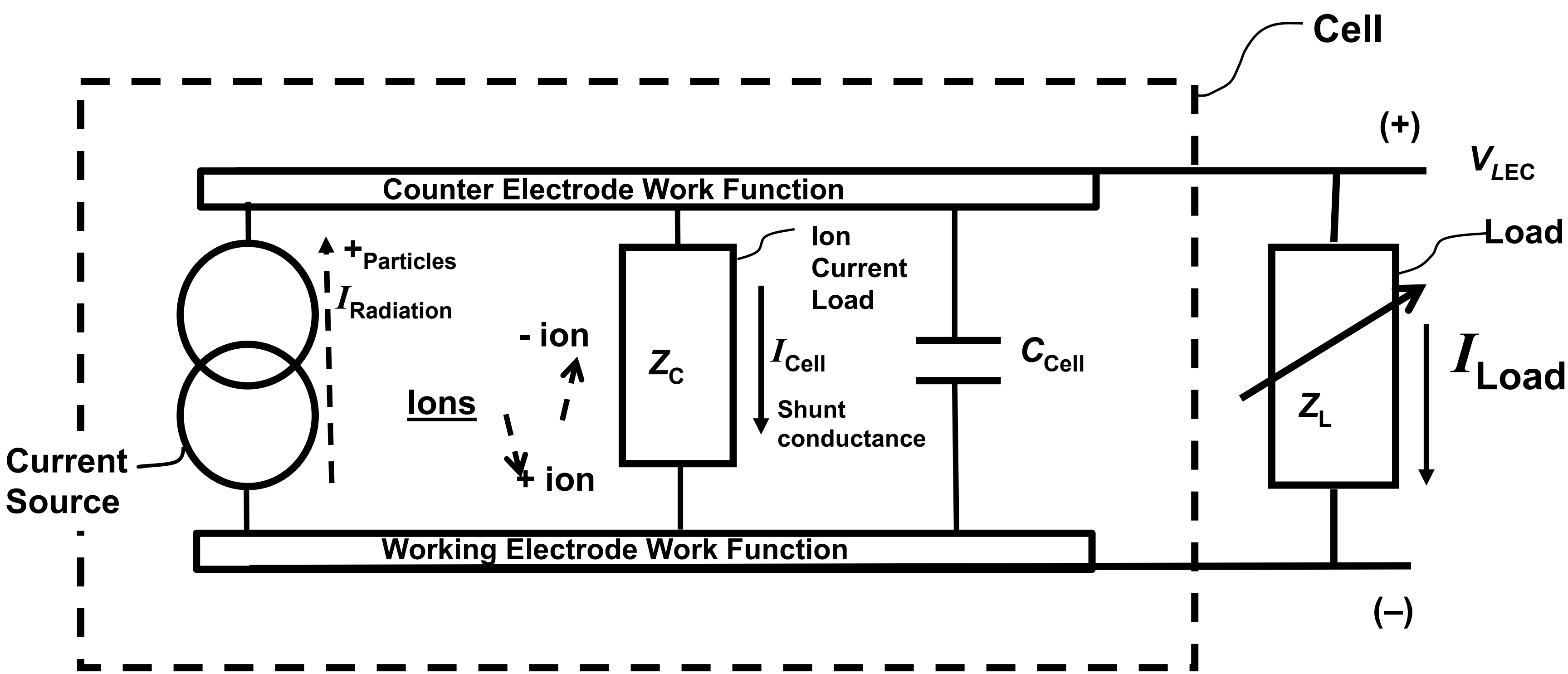


These power versus load resistance plots were calculated from the cell voltage versus load resistance data in the previously presented. In this slide Power = (Voltage × Current) = $(\text{Voltage})^2$ / Resistance for each temperature and external load resistance. For a two-terminal device the maximum output power occurs when the external load impedance matches the device's internal impedance. For a current source, such as a LEC device, the internal impedance is very high and the power delivered to a load impedance increases monotonically with increasing load impedance. This behavior is clearly shown by the above power plots for low values of the load resistance. However, these power plots indicate that a LEC cell's internal impedance is both temperature dependent and is lower at higher temperatures due to the higher ionization flux increasing a voltage variable shunt conductance internally within the cell. This is consistent with other experimental data since an increase in radiation flux causes an increase in the ionization of the gas and more gas ions drifting at higher electric field strength produces an increase in conduction of the gas.

Phenemonlogical Equivalent Circuit

Lattice Energy Conversion (LEC) Device

Phenomenological Norton equivalent circuit representation of the of the processes within the cell based on observed experimental data



LEC Shunt Conductance

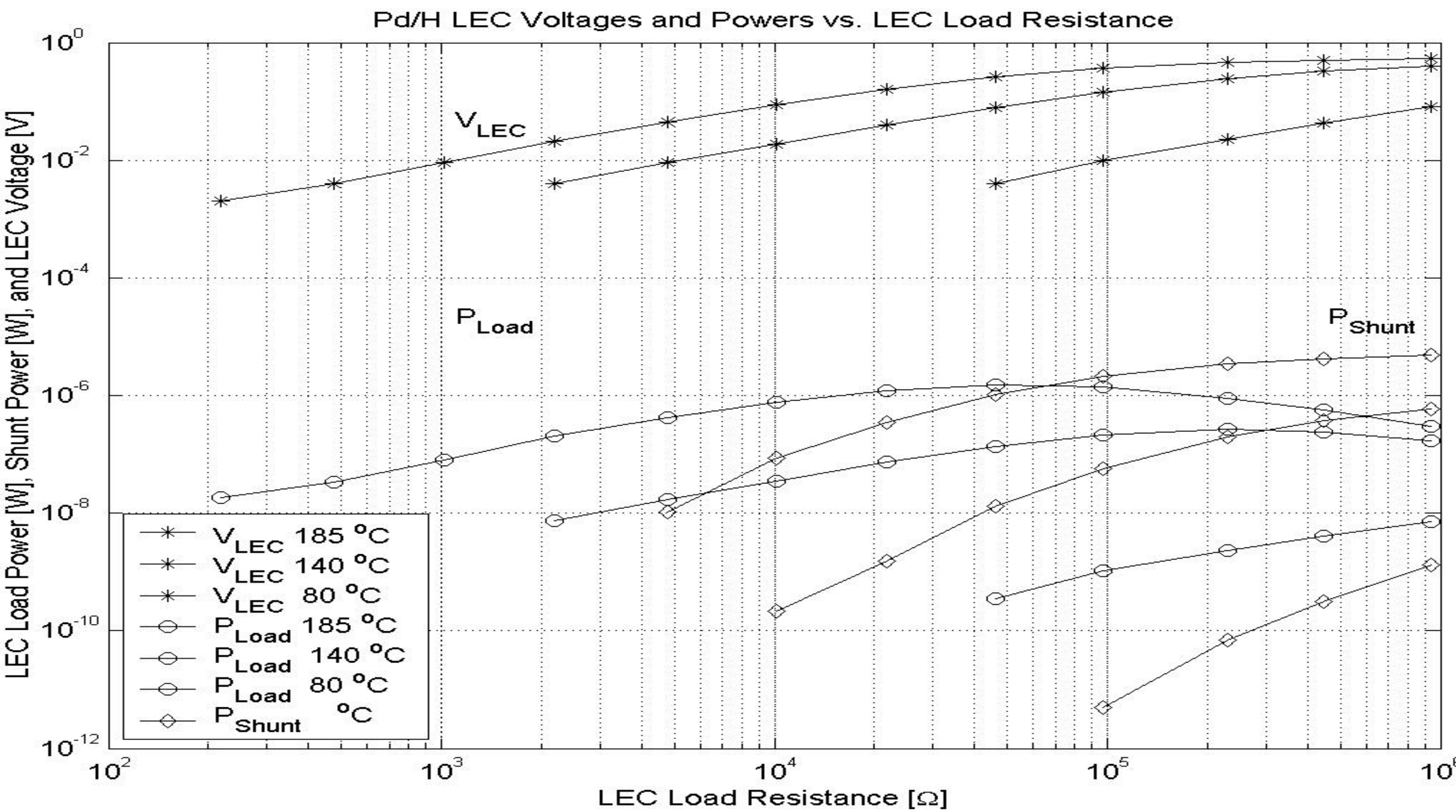
- The shunt conductance term in the phenomenological equivalent circuit represents an internal loss of the spontaneous conduction current from the load
- In some respects a LEC is similar to an ionization chamber with an internal source of radiation
- To better understand the nature of the shunt conductance a LEC cell can be operated as an ionization chamber by using an external voltage and measuring the resulting conduction current
- In order to maximize the available power to the load the load resistance may be adjusted to reduce the load voltage and thus reduce the shunt current
- Shunt conductance can also be minimized by cell designs as well as by adjusting the load impedance

The shunt conductance term in the phenomenological equivalent circuit represents an internal loss of the spontaneous conduction charge-current from the load. In some respects, a LEC is similar to an ionization chamber with an internal source of radiation. To better understand the nature of the shunt conductance a LEC cell can be operated as an ionization chamber by using an external voltage and measuring the resulting conduction current (I-V). From the I-V measurements the conductance of the gas at a fixed voltage can be computed as the ratio of I/V = G.

In order to maximize the available power to the load the load resistance may be adjusted to reduce the load voltage and thus reduce the shunt current. Shunt conductance can also be minimized by cell designs as well as by adjusting the load impedance Cell geometry to deal with shunt conductance.

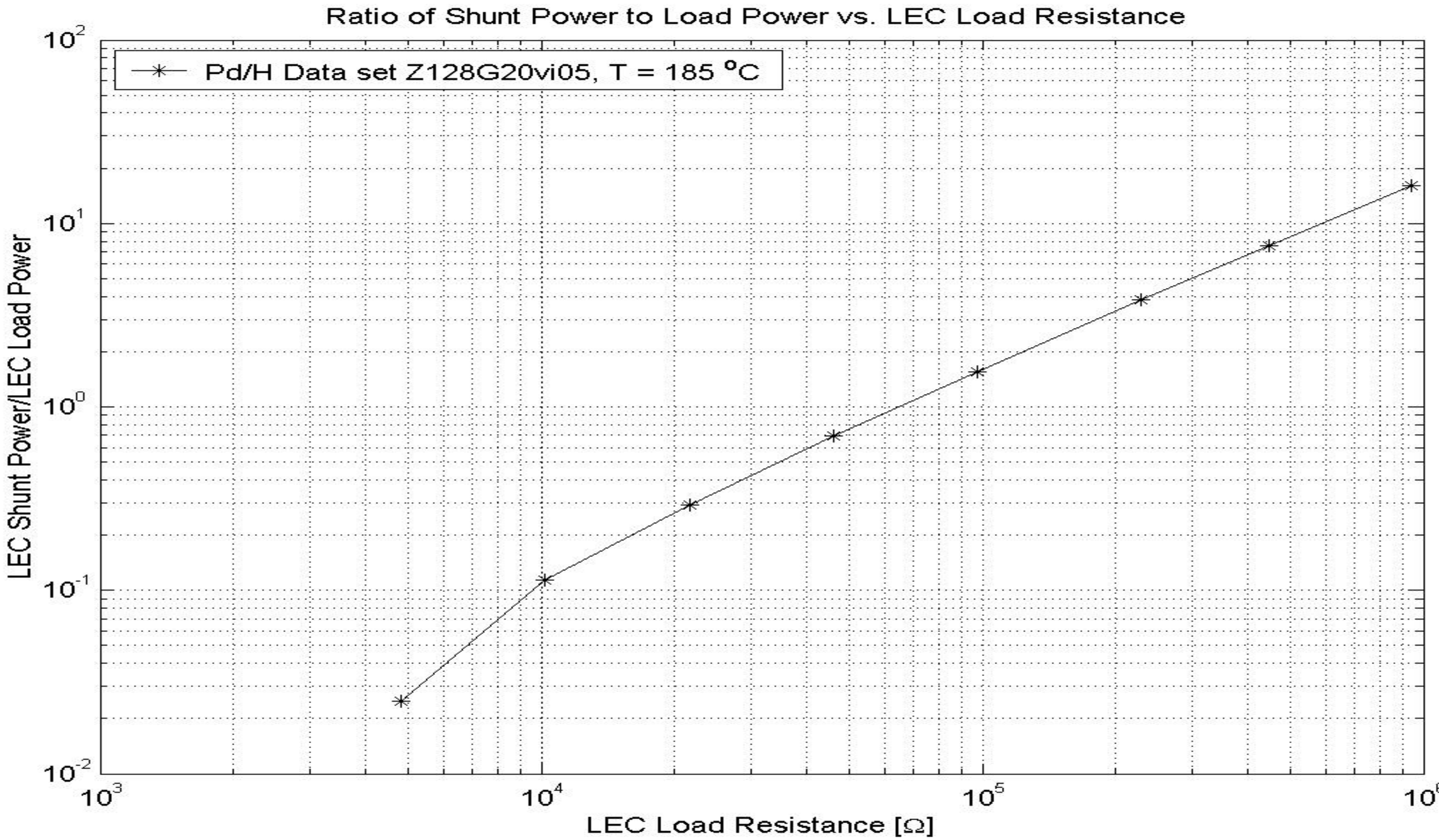
Spontaneous Load and Shunt Power

T = 80, 140, and 185 °C



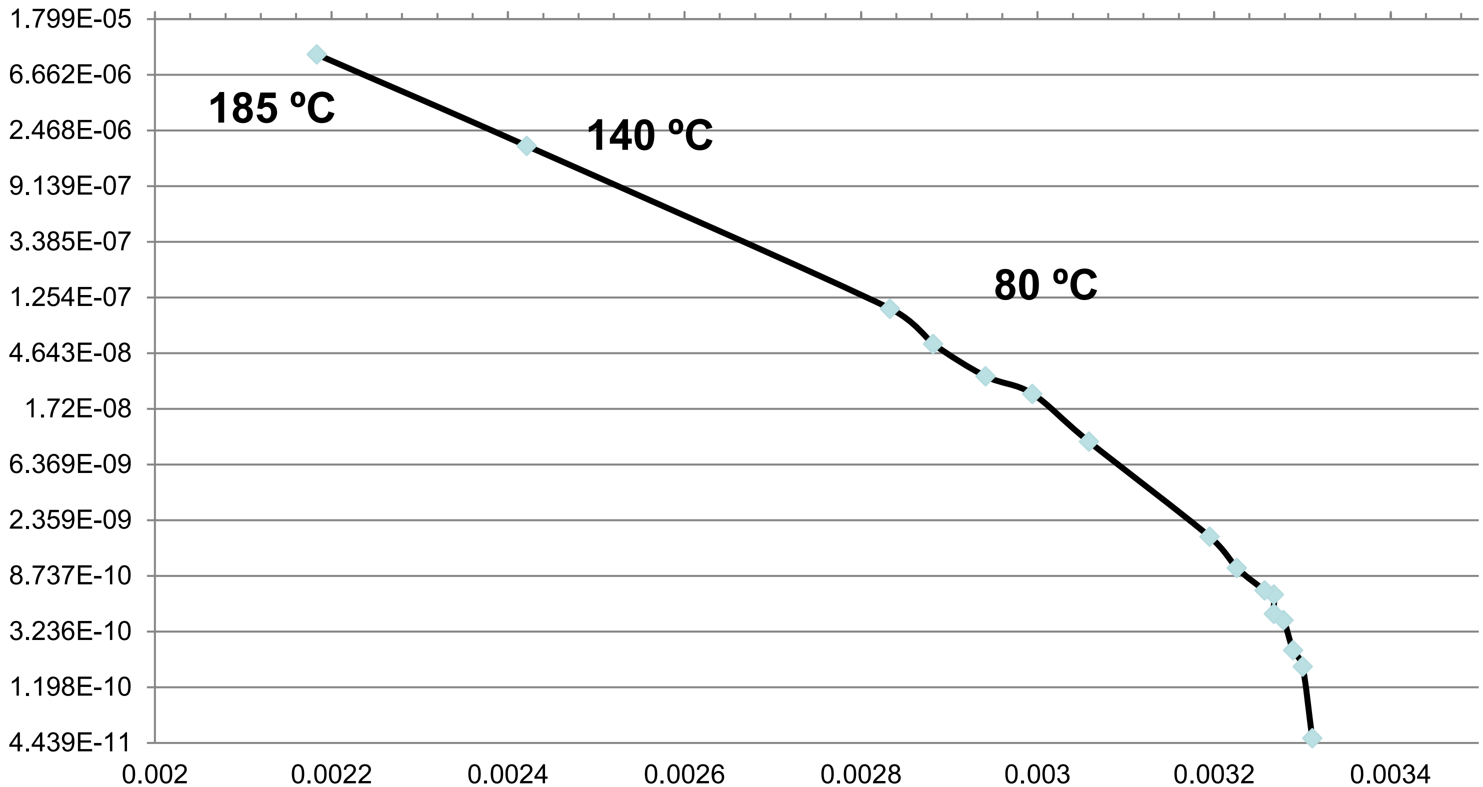
Ratio of Shunt Power to Load Power

vs. Load Resistance at T = 185 °C



Arrhenius Plot of Maximum Load Power

Temperatures from 29 ºC to 185 ºC



The activation energy is a function of the slope of the line. Between 80 ºC and 185 ºC, the activation energy based on current is 0.601 eV. At lower temperatures the activation energy ranges from about 4 to 1. Note that vacancies also increase with temperature

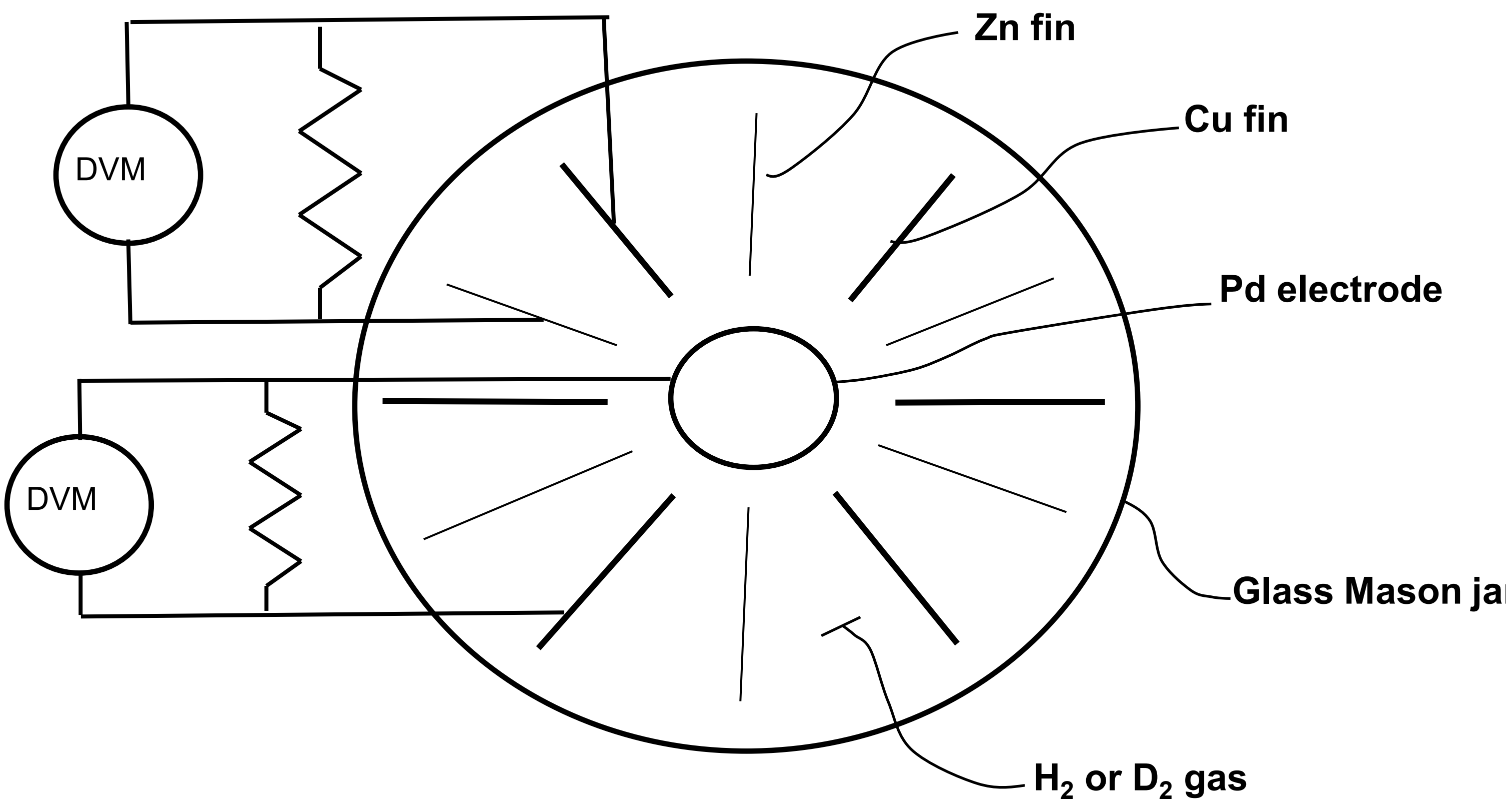
LEC Performance Observations for Simple Two Electrode Geometry

- Radiation current is approximately constant for all measured load resistances and increases with increasing temperature
- Maximum load power occurs for different load resistance as LEC temperature increases
- Maximum load power increases approximately exponentially with increasing lattice temperature
  - Shown by the Arrhenius curve of $\ln(P_{max})$ vs. $1/T$ in kelvin
  - Lower load resistance needed for higher temperature
- Physics of the shunt current or gas ionization should be studied further to optimize LEC Performance

Alternative LEC Cell Design

To exploit the shunt current to produce a Contact Potential Difference or Volta potential

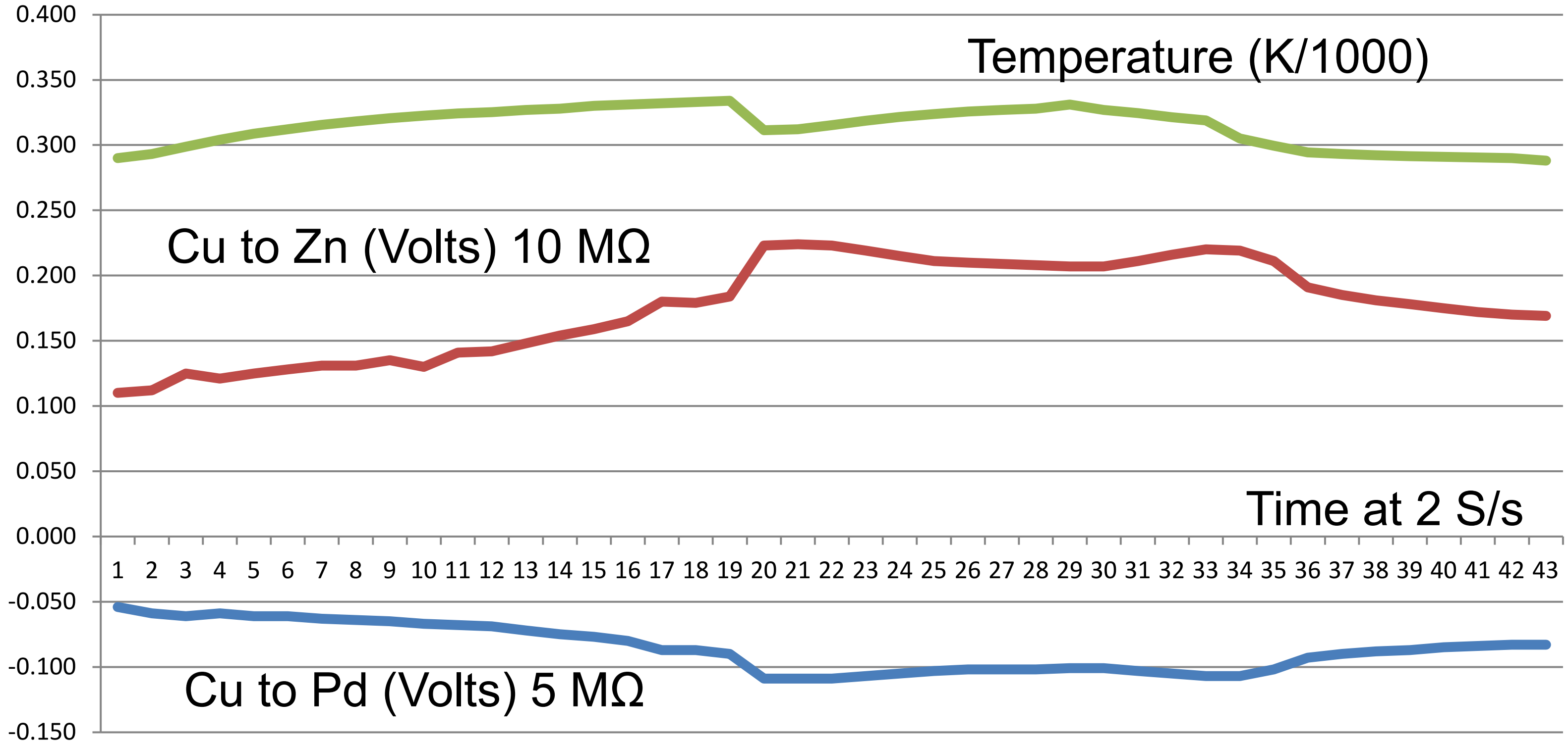
A cross-section view of a contact potential difference cell with fin structures of different work function to harvest the energy.



Shown is a simplified cross-section view of a cell design that includes alternating fins of copper (Cu) and zinc (Zn). The active working electrode is positioned in the center and deuterium gas at approximately ambient pressure fills the container. The container for this cell is a Mason jar which was selected to provide a longer ionization path distance between the ionization source of the working electrode and the fins in order to exploit the Volta potential or contact potential difference phenomena which depends on the density of ionization between the fin electrodes and where most of the ionization occurs at the distance corresponding to the peak of the Bragg curves Two sizes of Mason jars have been used; one allowing a 3½ inch max diameter electrode configuration and the other with a wide mouth mason jar that allows about a 4 inch diameter electrode configuration. This cell design was constructed to take advantage of the I_{Cell} current which competes with the $I_{\mathrm{Radiation}}$ current as shown in the following schematic representation. Multiple fin-cell designs have been constructed and tested including 6 Cu and 6 Zn fins in alternating positions and also with 2 longer adjacent Cu fins alternating with 2 longer adjacent Zn fins. With the Cu fins connected together and the Zn fins connected together, the voltage is measured between the connected fin structures with a DVM.

Alternative Cell Design Voltages

Plots of the spontaneous LEC voltages between the fins and the 'active' electrode in a cell configured as shown in the previous slide.



Shown is a plot of data from a fin LEC cell described in the previous slide which shows the cell temperature and the voltages measured between the copper (Cu) fin to the palladium (Pd) coated working electrode and the Volta voltage or contact potential difference voltage between Cu fin structure to the zinc (Zn) fin structures. These results clearly show the presence of Volta or contact potential difference phenomena. Also, the voltage produced between the fin structures is a result of the different work functions and the ionized gas between the fins. A physical connection, i.e., a wire, between the fins and the working electrode is not required however there is an electrical connection through the ionized gas.

LEC Results vs. Thompson Predictions

- JJ Thomson's analyses do not include the presence of spontaneous radiation emanating from one of the electrodes
- Two electrode (working vs. counter electrode) induced conduction does not correspond to predictions (Thomson & Thomson, 3rd Ed, V I, 1928)
  - LEC Induced current vs. voltage did not saturate as predicted
  - Measured current vs. voltage greater than predicted for radiated particles with constant velocity (INOVL, 2020)
  - Measured current vs. voltage (I-V) greater than predicted for ions all of the same sign (Thomson, 1911)
- Alternative multi-electrode geometries may offer attractive alternative LEC implementations

Conclusions, Observations, and Speculations

- **Something is ionizing the gas**
  - The source of the energy to ionize the gas is Pd-H or Pd-D lattice
  - The specific ionization produced (α, β, Electromagnetic) is not identified
  - The flux of ionization increases monotonically with increased temperature
  - The mechanism that produces the ionization is unknown
  - Experimental evidence indicates that vacancies, including superabundant vacancies are important
- **These results provide strong evidence that low energy reactions occur in surprising places**
  - They may be related to documented biological transmutations
- **More research is needed**

Recent Discovery of Hidden Treasure

Rout, R.K., Srinivasan, M., et al., *Reproducible, anomalous emissions from palladium deuteride/hydride*. Fusion Technol., 1996. 30: p. 273. (Available in LENR-CANR library)

From the last two paragraphs of the conclusions:

> "The phenomena, though most easily reproducible in palladium, are perhaps more universal and may also be occurring when H2/D2 is loaded into other metals.
>
> All the mechanisms (known to us) which might have fogged the films, were considered and ruled out. Therefore, it is proposed that some new, unknown agency emitted from loaded palladium is responsible for fogging. It is felt that further study will not only give some additional insights for understanding this phenomenon, but it may also provide explanations for other anomalous effects observed in metal-hydrogen systems."

Acknowledgments

- The organizers of this workshop
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- Robert Means: review and comment
- Melvin Miles: Supplies, instrumentation and multiple discussions
- Dr. M. Srinivasan: For more than 31 years of leadership to the community

Thank You for you Attention

Lattice Energy Converter (LEC)

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