



SunCell® Demonstration Reaction Vessel – As Tested



Reaction Chamber (interior) – As Tested



Insulated SunCell® Demonstration System

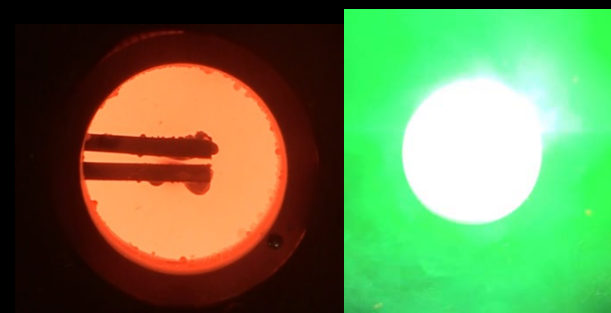
SunCell® Power Output Verification Validation Report Summaries

Dr Peter Mark Jansson PE

President & Principal Consultant – INTEGRATED SYSTEMS

Associate Professor – Electrical and Computer Engineering - Bucknell University

Senior Member ***IEEE***



Aims of this talk

- Summarize the features and operation of the SunCell® demonstrator reactor unit(s) as tested by the independent validators
- Introduce you to the measurement and analytical method used to determine SunCell® power inputs and output
- Review the various findings and observations of the four independent SunCell® validating scientists

Personal mission...

Advancing the knowledge and technologies that make sustainable living affordable on planet Earth

Focus areas include: smart grid, smart home, photovoltaic system optimization, sustainable transportation and new technology research

My background –

BS – Massachusetts Institute of Technology (Course I) '78

MSE – Rowan University – College of Engineering (ECE) '97

PhD – University of Cambridge – Industrial Engineering '03

21+ years experience in electric power industry (Atlantic Energy) and consulting

INTEGRATED SYSTEMS founded in 1986


16 year in academic / research posts (Bucknell & Rowan)

Professional Engineer in New Jersey '86 and Pennsylvania '07

Senior Member – IEEE (Power & Energy, Instrumentation & Measurement, AES)

Member – NSPE, ASCE and Former Member – EPRI, EEI, USAPV, AIAA, ISIE

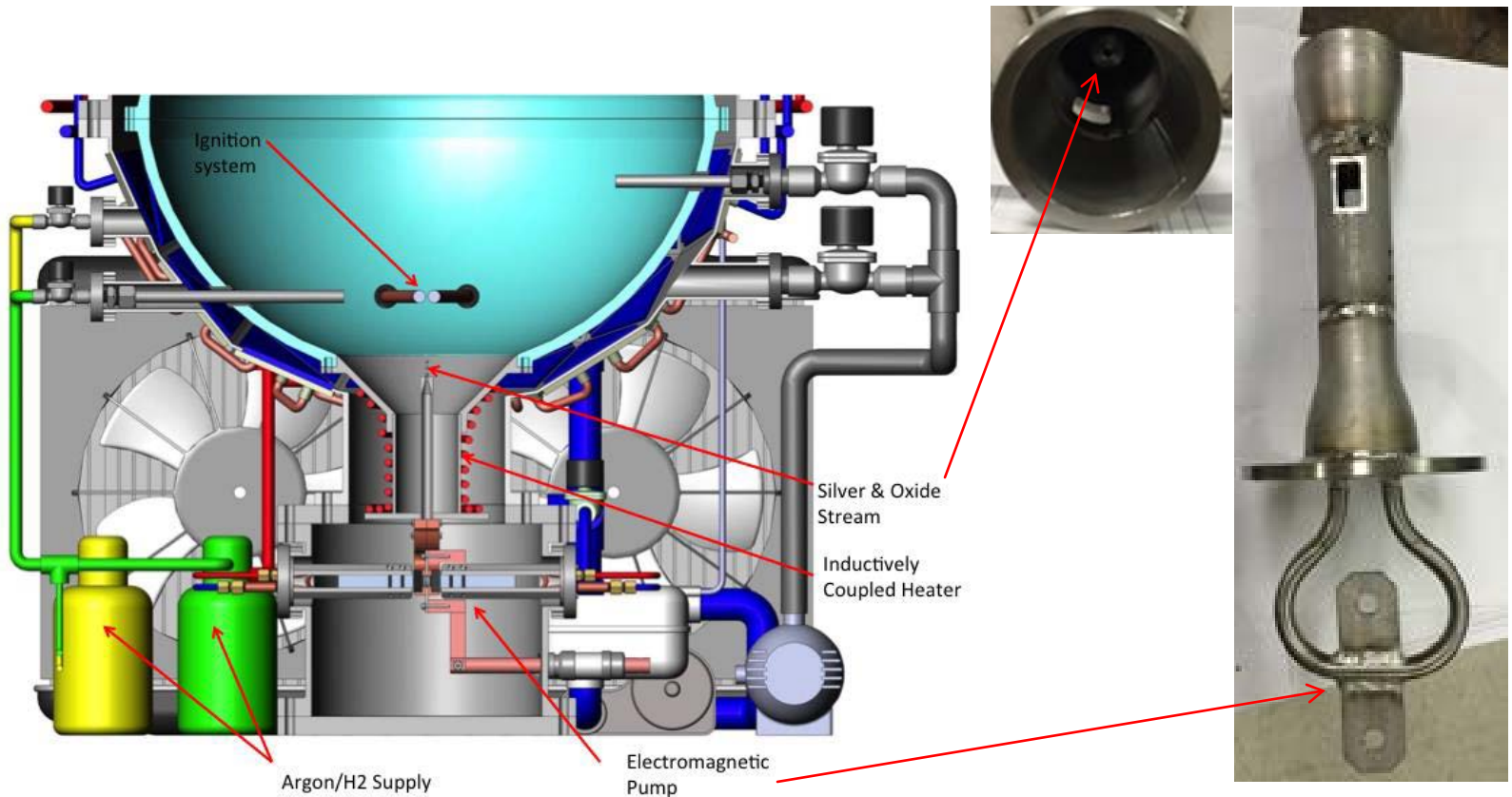
> 120 technical, peer reviewed publications and presentations

 Integrated Systems

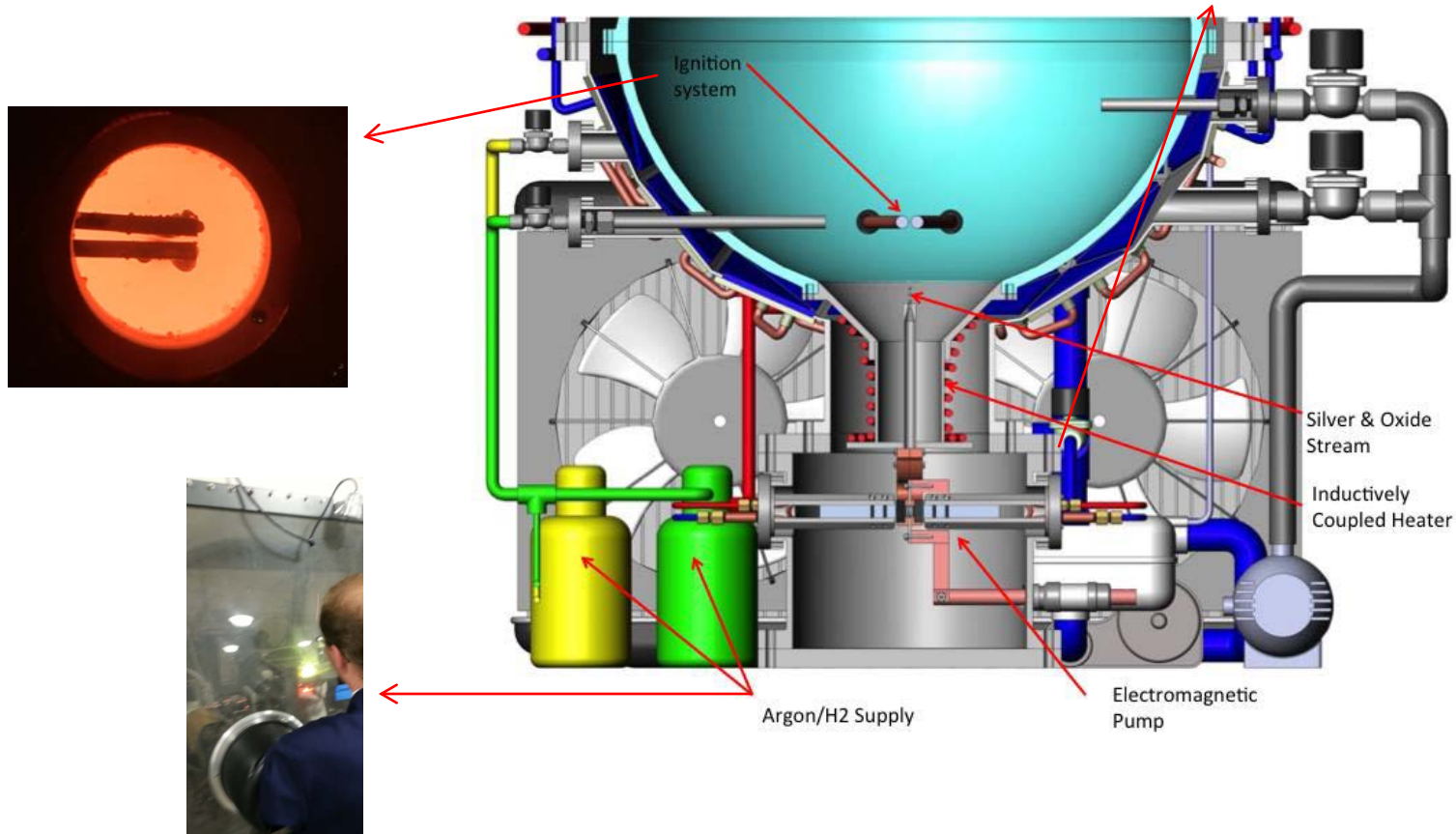
- You see things; and you say “Why?” But I dream things that never were; and I say “Why not?”

- GEORGE BERNARD SHAW, *Back to Methuselah*, act I, *Selected Plays with Prefaces*, vol. 2, p. 7 (1949)

SunCell® Demonstrator Overview



SunCell® Demonstrator Overview



SunCell® Power Measurement Overview

- To determine power being produced by the SunCell® demonstrator the cooling system heat gain was continuously monitored
- All input powers (electrical) were captured on a digital oscilloscope (voltages and currents)
 - Inductively coupled heater
 - Ignition system electrodes
 - Electromagnetic pump

SunCell® Independent Validations

- Dr. Joseph D. Renick: 22-23 April 2016
 - Independent Consultant, Albuquerque, New Mexico
- Dr. K.V. Ramanujachary: 20, 26-27 April 2016, 5 May 2016
 - Department of Chemistry and Biochemistry
 - Rowan University, Glassboro, New Jersey
- Dr. Peter Mark Jansson, PE: 5 May 2016
 - President/Principal Consultant – INTEGRATED SYSTEMS
 - Department of Electrical and Computer Engineering
 - Bucknell University, Lewisburg, Pennsylvania
- Dr. Randy Booker: 23-24 May 2016
 - Department of Physics
 - University of North Carolina - Asheville

Dr. Joseph D. Renick – Independent Consultant

- “A nice aspect of this experiment is that its characterization depends on heating rate rather than temperature difference. Consequently, the only measurements required are input power to the IC heater, EM pump and electrodes, and temperature measurements in the antenna coil of the cooling system for the IC heater which directly registers thermal output of the reactor.”

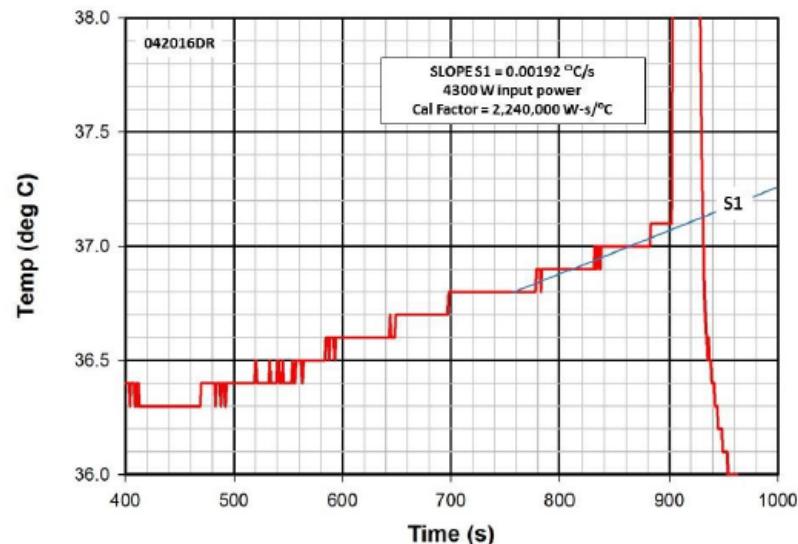


Figure 3. Heating due to IC heater and EM pump power input prior to ignition.

Dr. Joseph D. Renick – Independent Consultant

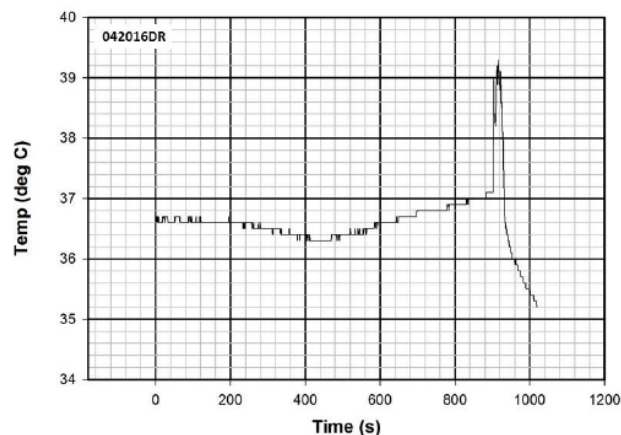


Figure 2. Temperature of antenna coil water, pre-ignition and ignition.

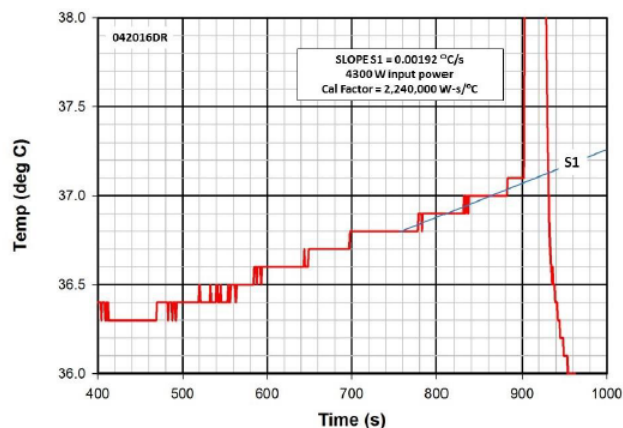


Figure 3. Heating due to IC heater and EM pump power input prior to ignition.

Gas Flow Rate: 9 liters/min Ar/H₂(3%)

RESULTS: Input Power Output Power Gain
22-23 April 2016

7,540W	2,052,000W	271x
7,540W	645,000W	86x

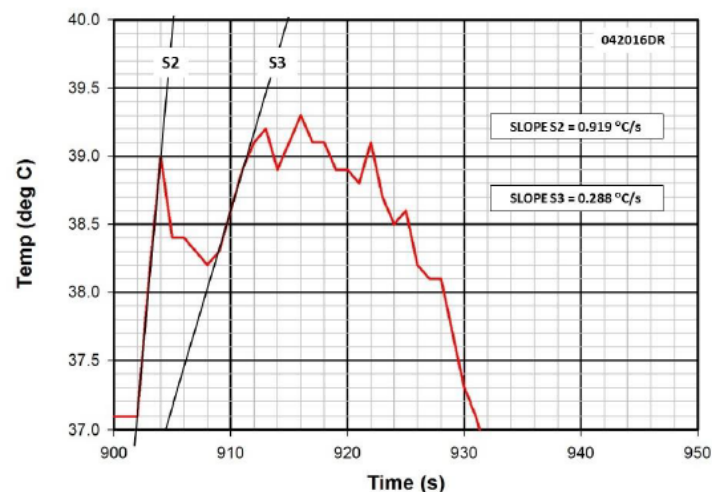
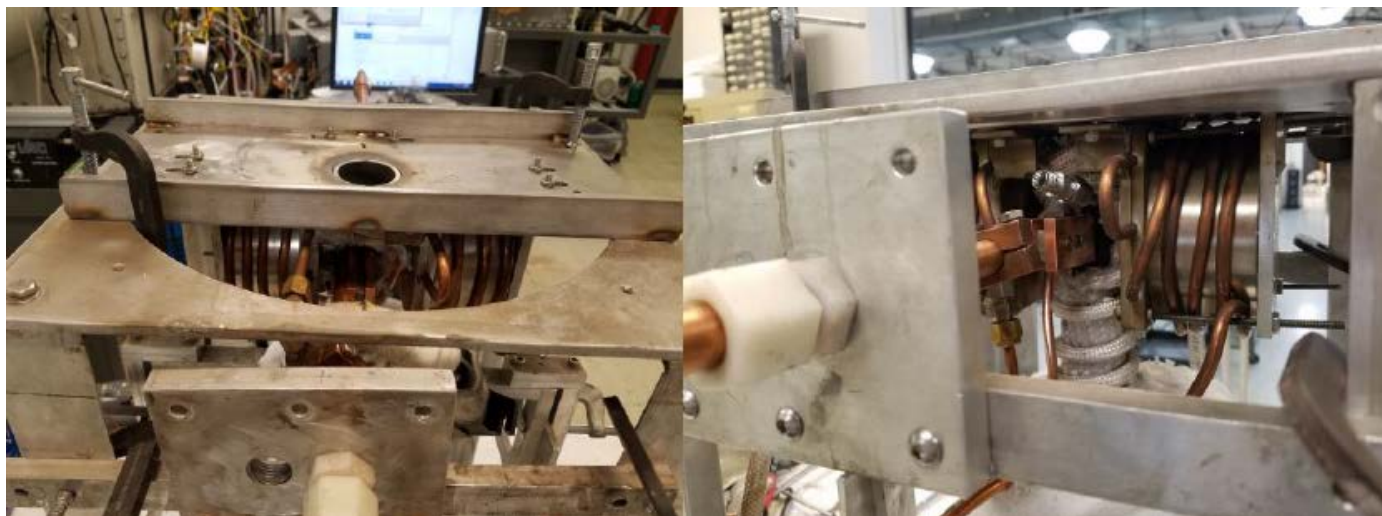


Figure 4. Expanded plot showing slopes of heating curves, S2 WO₃ reaction, S3 Bi₂O₃ reaction.

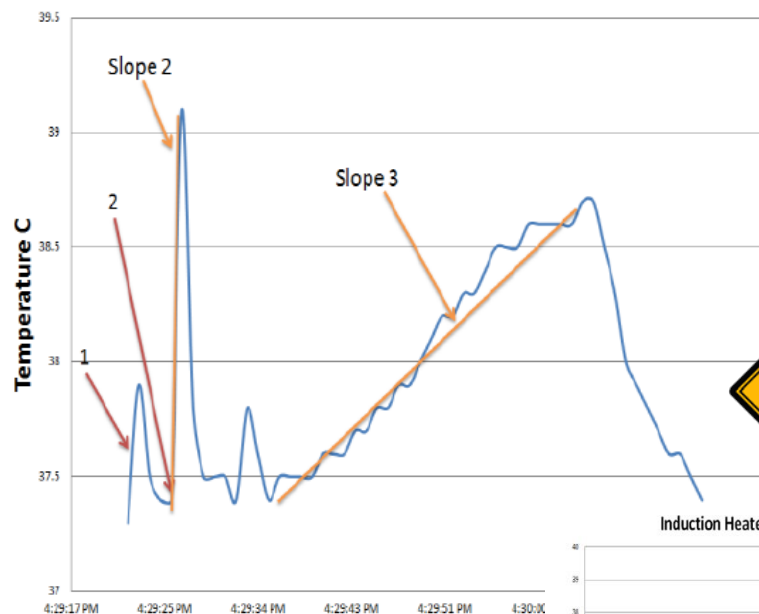
Dr. K.V. Ramanujachary — Department of Chemistry

- “the observed reaction powers of 731,000 W (97x); 987,700 W (119x); 126,000 W (15x); 5,220,000 W (538x); 1,567,000 W (181x); 433,100 W (54x), and 282,150 W (27x) were of the same magnitude as those recorded by absolute spectroscopy over the wavelength region 5-800 nm ... and reduction of (reactants) can provide a trivial power contribution of less than 18.6 W ”



Dr. K.V. Ramanujachary – Department of Chemistry

Circled Area

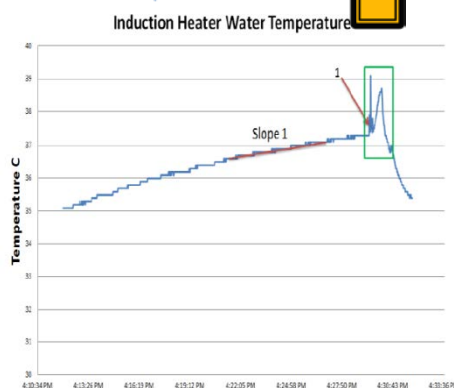


Gas Flow Rate: 9 liters/min Ar/H₂(3%)

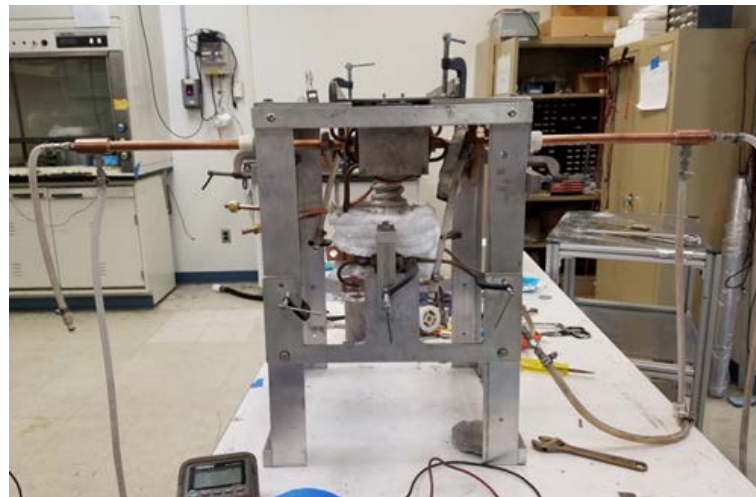
RESULTS: Input Power
20, 26-27 April 2016, 5 May 2016

Output Power Gain

7,540W	731,000W	97X
7,540W	2,576,000W	341X
8,300W	987,000W	119X
8,400W	126,000W	15X
9,700W	5,220,000W	538X
8,660W	1,567,000W	181X
8,020W	433,000W	54X
10,450W	282,000W	27X



- “The method used to calculate output power based upon slope changes in the coolant are well documented in Appendix 4 (part IV) and have been developed based on standard thermal modeling.... As can be observed by close examination of these curves, the “active” reaction times (when coolant water temperature rises are obvious) were on the order of 1 to 3 minutes in duration. IS was able to observe a more continuous SunCell® reaction experiment that lasted 7 minutes and 15 seconds. ”



Gas Flow Rate: 9 liters/min Ar/H₂(3%)

RESULTS: Input Power Output Power Gain
5 May 2016

8,020W	521,000W	65x
10,450W	1,560,000W	149x

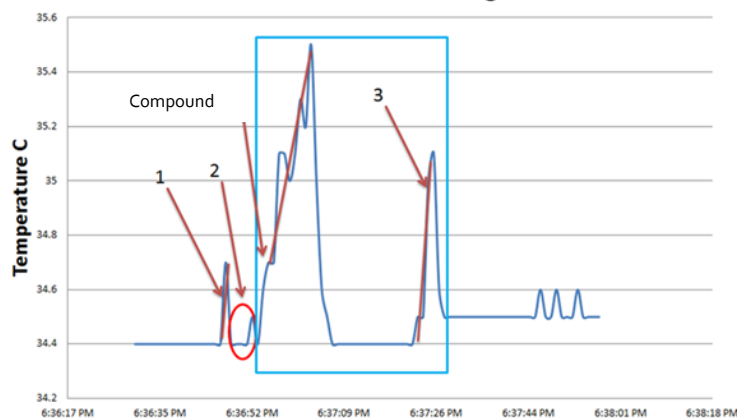


Fig 12 – Coolant Water Temperature Highlighting Red Box Region in Fig 11 Above

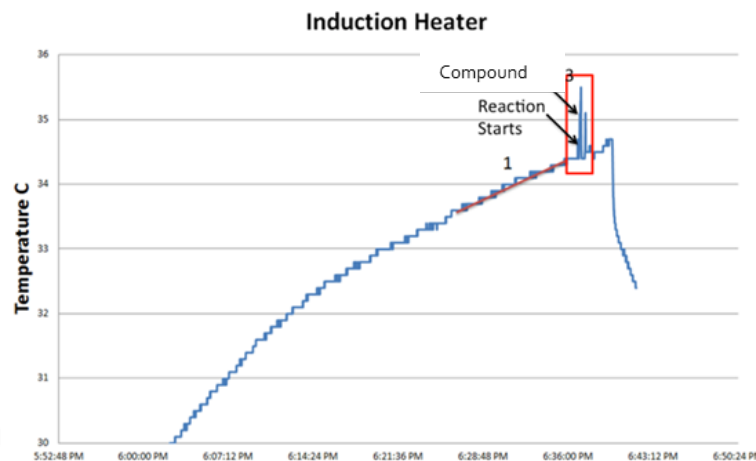
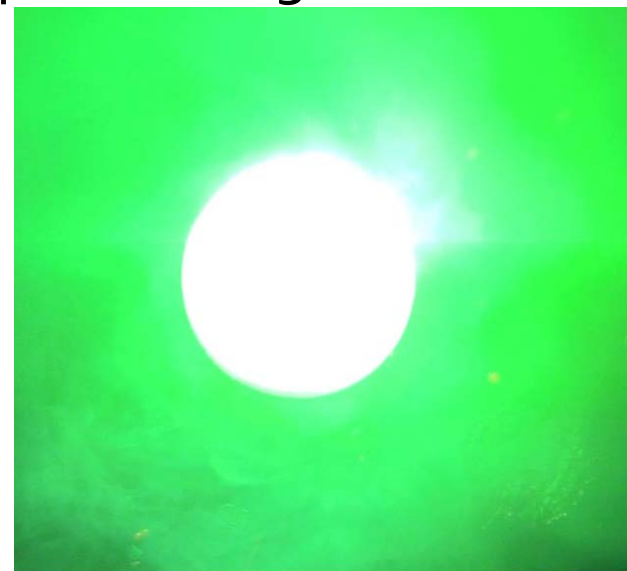
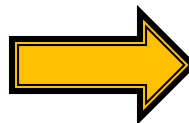
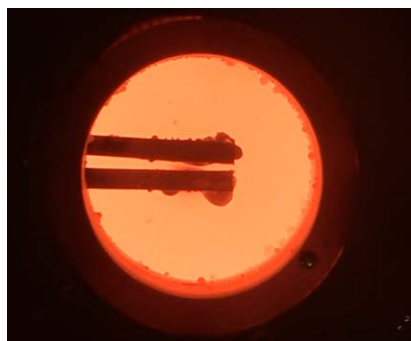
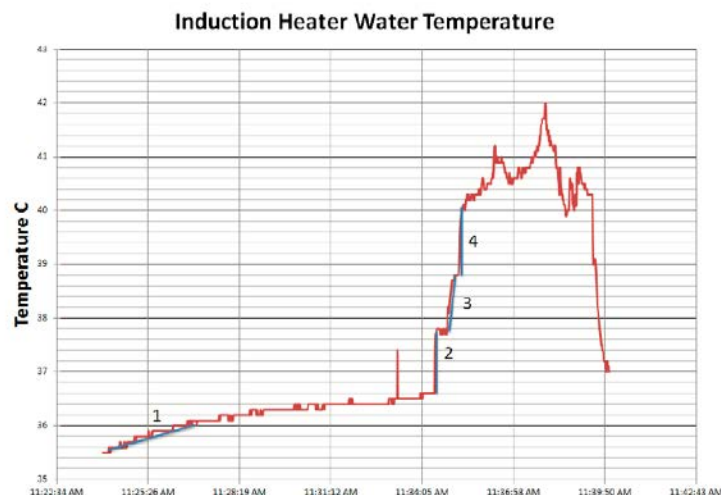


Fig 11 – Coolant Water Temperature of SunCell® Demonstration Reactor System vs. Time- 050516BDR

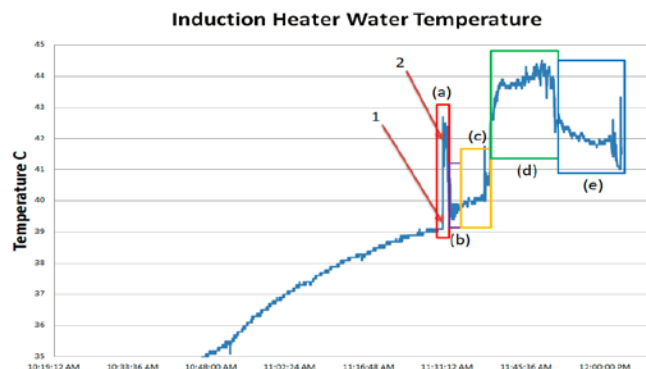
- “The reaction occurs very abruptly, causing the cell to go from the nice red-orange color of the heating system of the silver to a very loud, explosive reaction that is green in color. At first, silver particles are seen to come off the open reaction cell. Then silver vapor is seen to come out at later times. In the first run the green explosive stage lasted for about 30 minutes – a long time!”



Dr. Randy Booker — Department of Physics



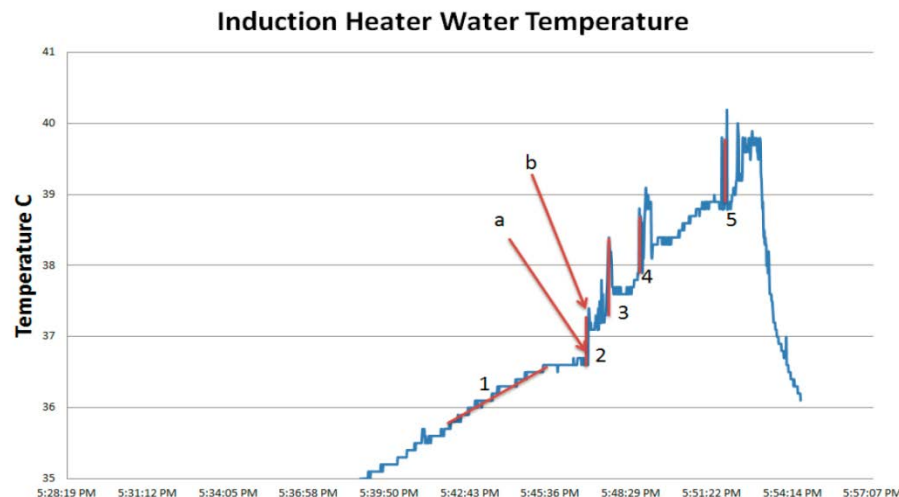
(B)



(A)

Gas Flow Rate: 9 liters/min Ar/H₂(3%)

RESULTS: <u>Input Power</u>	<u>Output Power</u>	<u>Gain</u>
23-24 May 2016		
5,020W	3,200,000W	637x
9,000W	1,800,000W	200x
8,790W	230,000W	26x



Validator's Observations

- Operation of SunCell® for multiple minutes in continuous plasma production.
- IS validator (Dr. Jansson) observed 1-3 minutes in typical power production duration and another test produced >7 minutes.
- Dr. Booker observed one production run exceeding 30 minutes

Validator's Observations





SunCell® demonstrator in the glovebox - post-ignition - 05 May 2016

Questions?

Presentation to Brilliant Light Power Industry Day – 26 October 2016