



Nanoramic™
LABORATORIES

World Oil® **HPHT**

DRILLING, COMPLETIONS & PRODUCTION CONFERENCE

October 30–31, 2018

Norris Conference Centers – CityCentre, Houston, Texas

HPHTConference.com

High Temperature Ultracapacitors for MWD and LWD Operations

Mitch Koffel

Director of Business Development
Nanoramic Laboratories

Nanoramic Company History

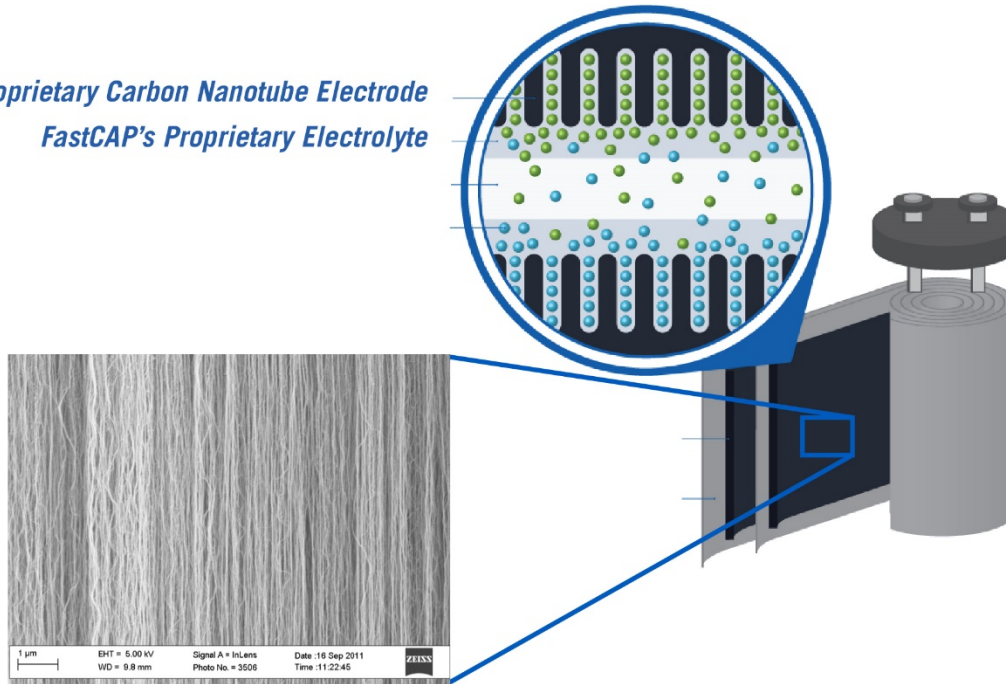
- 2009: FastCAP Systems founded with \$5.3M DoE ARPA-E Grant: CNT (Carbon Nanotube)-based Ucap Electrodes
- 2010: Development of world's first High Temperature Ucap
- 2012: \$2.2M DoE Geothermal Grant: Very High Temp Ucaps
- 2014-present: NASA, DoD - very high performance, exotic temp. range Ucaps, Structural Ucaps
- 2016: first commercial Harsh Environment Ucap
- 2017: New products under development: Surface Mount Reflowable Ucap, Announced Advanced Materials Business Line
- 2018: Rebrand to Nanoramic Laboratories and FastCAP Ultracapacitors



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Nanoramic's Core Technology: CNT Ucaps

FastCAP's Proprietary Carbon Nanotube Electrode
FastCAP's Proprietary Electrolyte



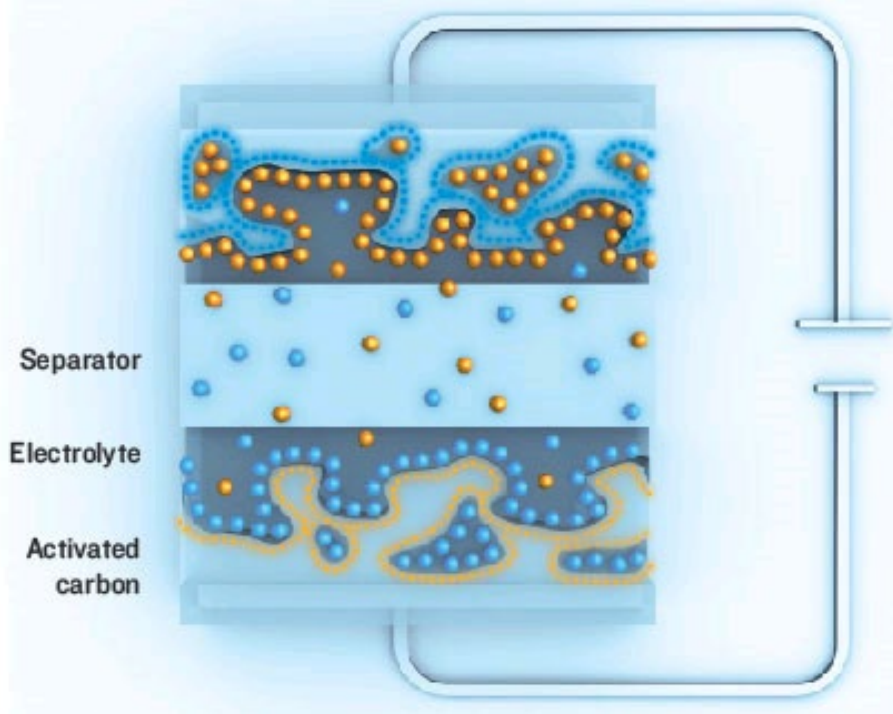
Notable attributes:

- Proprietary carbon nanotube electrode with high surface area
- Proprietary electrolyte for high stability at high temperature
- 10x the power density of incumbent ultracapacitors
- 3x energy density

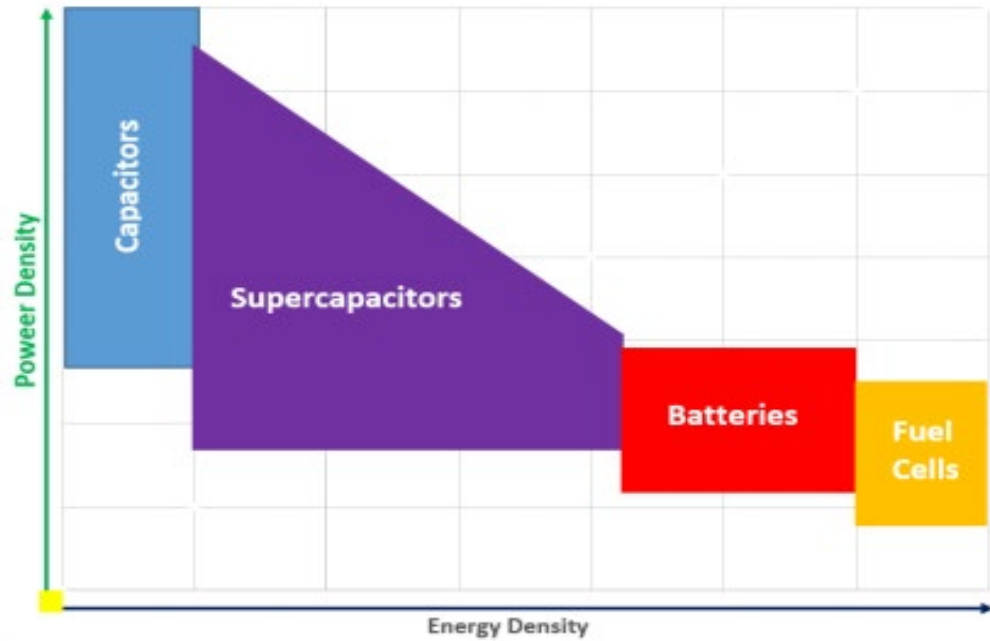
What is an Ultracapacitor?

Notable attributes:

- ☛ Store energy in electric fields. Not based on chemical reactions like batteries
- ☛ Recharge very quickly
- ☛ Provide much higher power than batteries
- ☛ Have a lower energy density than batteries
- ☛ Have very long lifespans and a stable shelf life, long cycle life
- ☛ Do not contain lithium



- 10-100 times higher energy density than tantalum or other electrolytic capacitors
- Very low ESR



	Wet tantalums	Nanoramic Ultracapacitor
Capacitance	1 - 50 mF	33 - 370 F
Voltage	4.2 - 6.3 V	1.0 - 2.0 V
Maximum Temperature	+85°C	+150°C
Minimum ESR	500mΩ	8 - 22 mΩ

Natural Time Constants as a Guide

“match the load behavior to the energy storage capabilities”



Dielectric
capacitors



Electrolytic
capacitors



Ultracapacitors



Batteries

p,n,u-seconds

m-seconds

10's of m seconds

10's of seconds

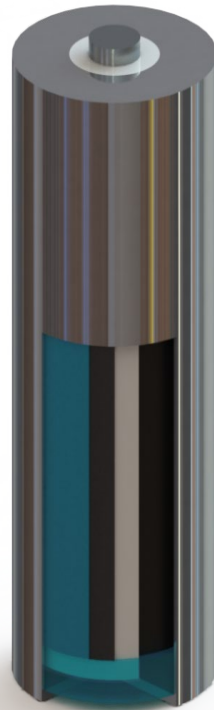
minutes

“if your load and energy storage time constant are very mismatched, you will have an a-priori disadvantage”

Application in Oil and Gas

Attributes:

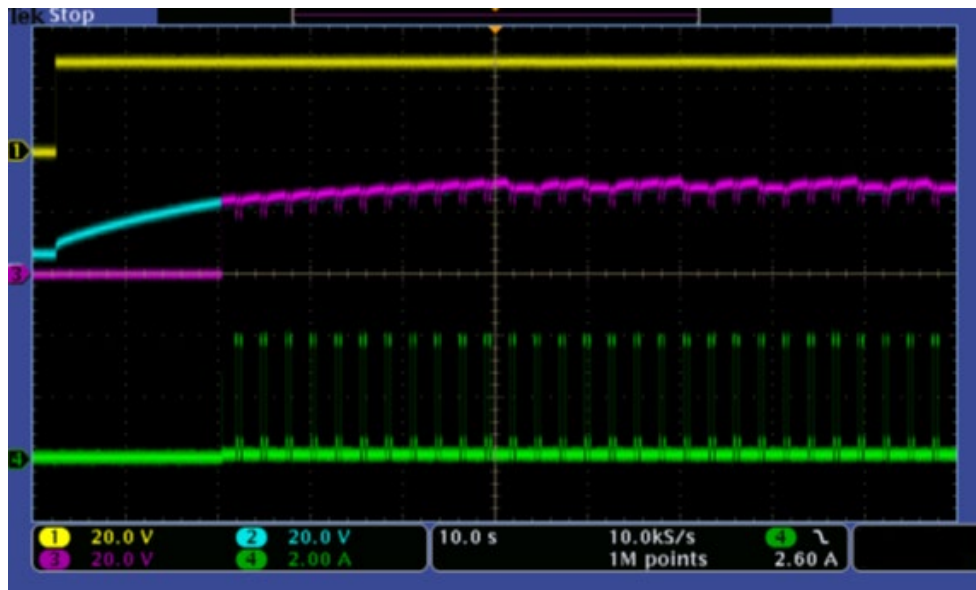
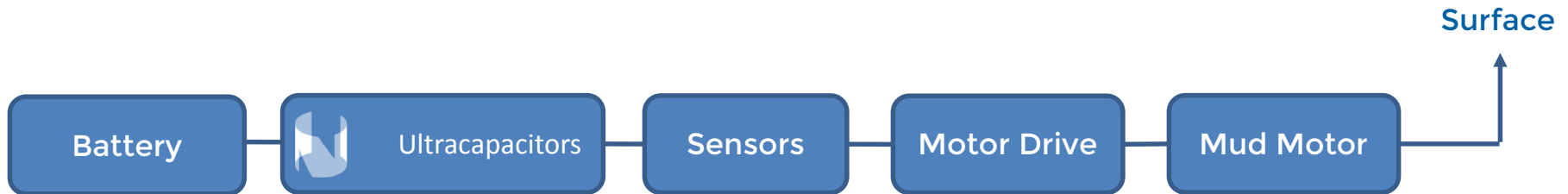
- Pulsed Power
- Rapid Cycling
- Low Duty Ratio
- Peaky Load



Applications:

- Power buffering for mud pulse telemetry
- Lithium free generator application
- Power boost for EM telemetry
- RTC back up for downhole products
- Frac operations and monitoring systems
- High Temperature tantalums

Power Buffering For Mud Pulse Telemetry



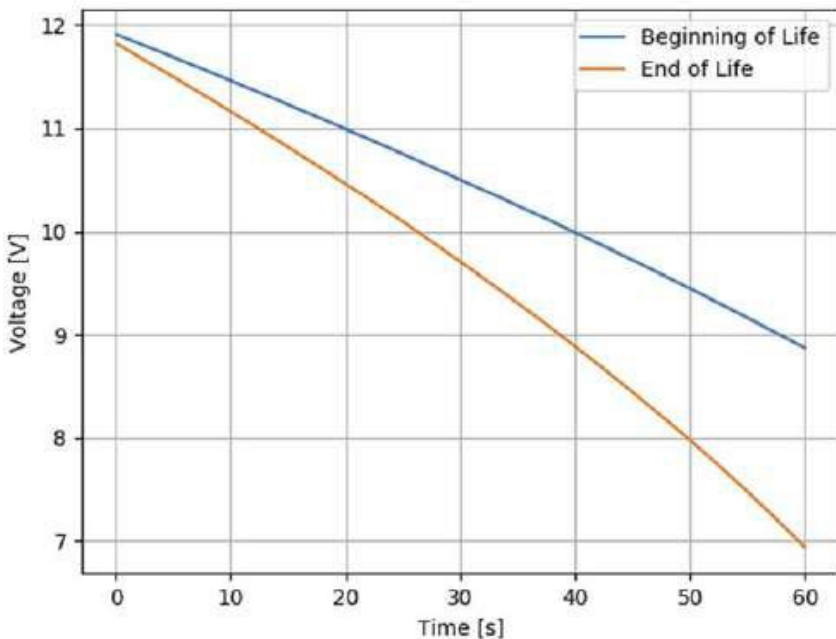
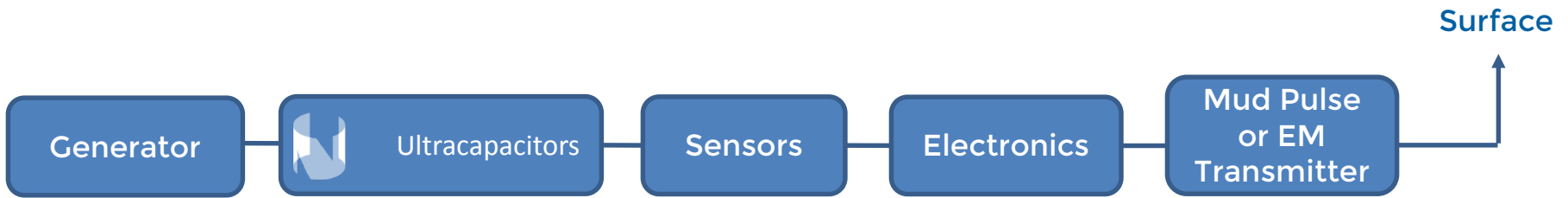
Benefits

- Handles power burst to open and close mud valve
- Unclog and disrupt the valve
- Improves peak current handling capacity of the battery
- Long lasting battery pack
- High performance mud pulse tool

CH1 Input battery voltage, remains stable due to the ultracaps buffering nature
 CH2 UCAP state of charge
 CH3 Output voltage lock out during first 18sec

CH4 Output pul current 1A pulses in rapid succession

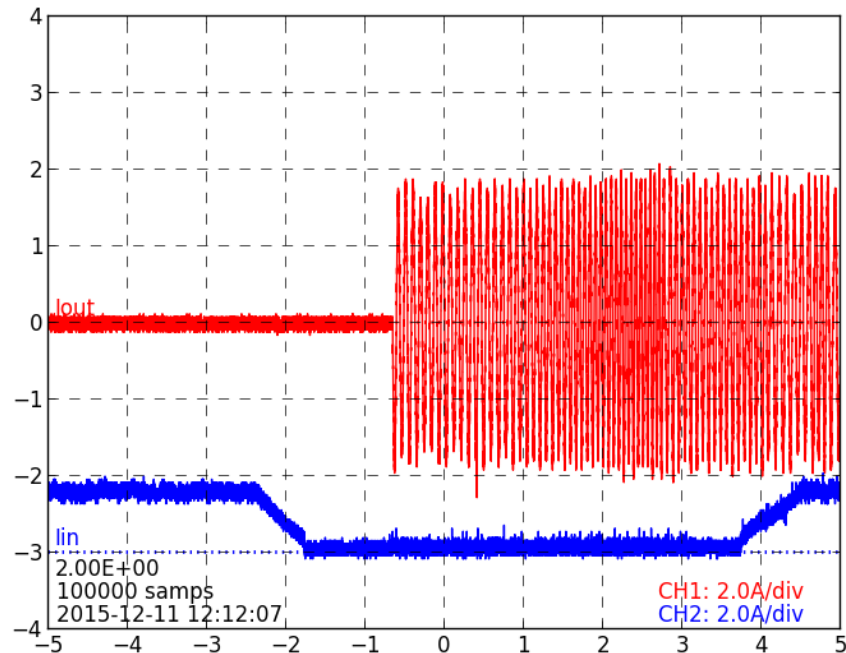
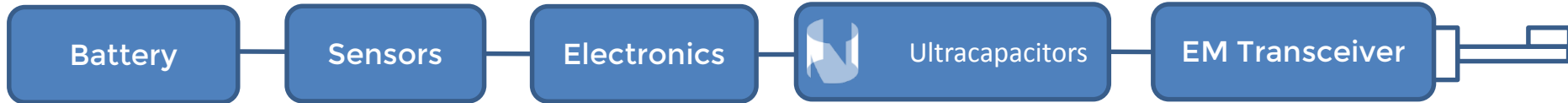
Lithium Free Generator Buffering Application



Benefits

- Ultracapacitors provide energy long enough to run until the drilling resumes and mud flow is back on

Lithium Free Generator Buffering Application



Benefits

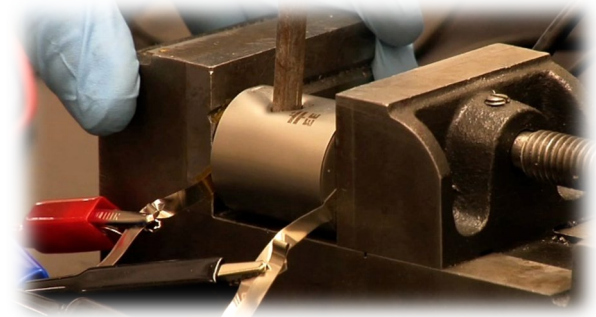
- Boosts the EM signal to surface
- High signal noise ratio
- Reliable signal even in tough formations

CH1 output current through test load
CH2 input current drawn from the battery

Downhole Ultracapacitor Safety and Abuse

Extensive abuse tests performed on FastCAP's ultracaps:

- Sawed in half while charged and cycling
- Punctured and shocked while charged and cycling
- Crushed while charged and cycling
- Boiled while charged and cycling
- Blow torched (1000C) while charged and cycling



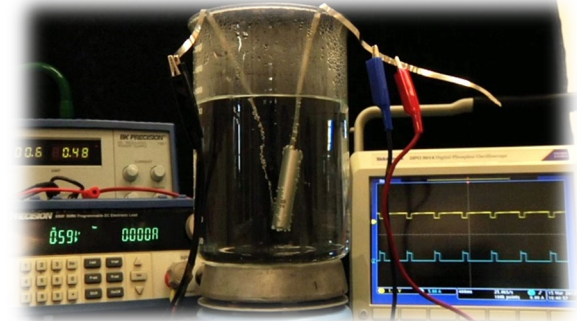
Puncture while charged
and cycling



Blow Torch Test while charged and cycling



Cut in half while charged
and cycling







Freeze to boil while charged
and cycling

Product Offerings

Product Code	Capacitance (F)	Voltage (V)	ESR (mΩ)	Max Temp (°C)	Format
EE100-350	370	2	8	100	D Cell
EE125-350	350	1.5	8	125	D Cell
EE150-350	345	1.0	8	150	D Cell
EE100-35	38	2	18	100	AA Cell
EE125-35	35	1.5	20	125	AA Cell
EE150-35	33	1	22	150	AA Cell

Endurance of Nanoramic Ultracapacitors

-  Lifetime at rated voltage and temperature of 1500 hours
-  Cycle life at 25°C >1,000,000 cycles
-  Lifetime at 25 °C > 15,000 hours
-  Shock and vibration 500Gpeak & 20Grms



AA Cell



D Cell

FASTCAP⁺

EXTREME ENVIRONMENT
ULTRACAPACITORS

Product Pipeline

Concept

Development

Commercial

Ultra Low Temp
Ultracapacitor

Defense
One-shot
Ultracapacitor

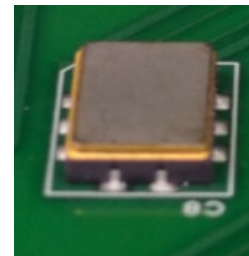
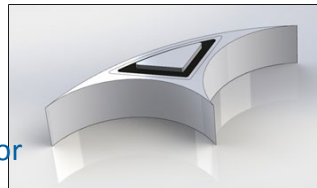
Aerospace Grade
Structural
Ultracapacitor

World's first and only
Low ESR Reflowable
Chip
Ultracapacitor

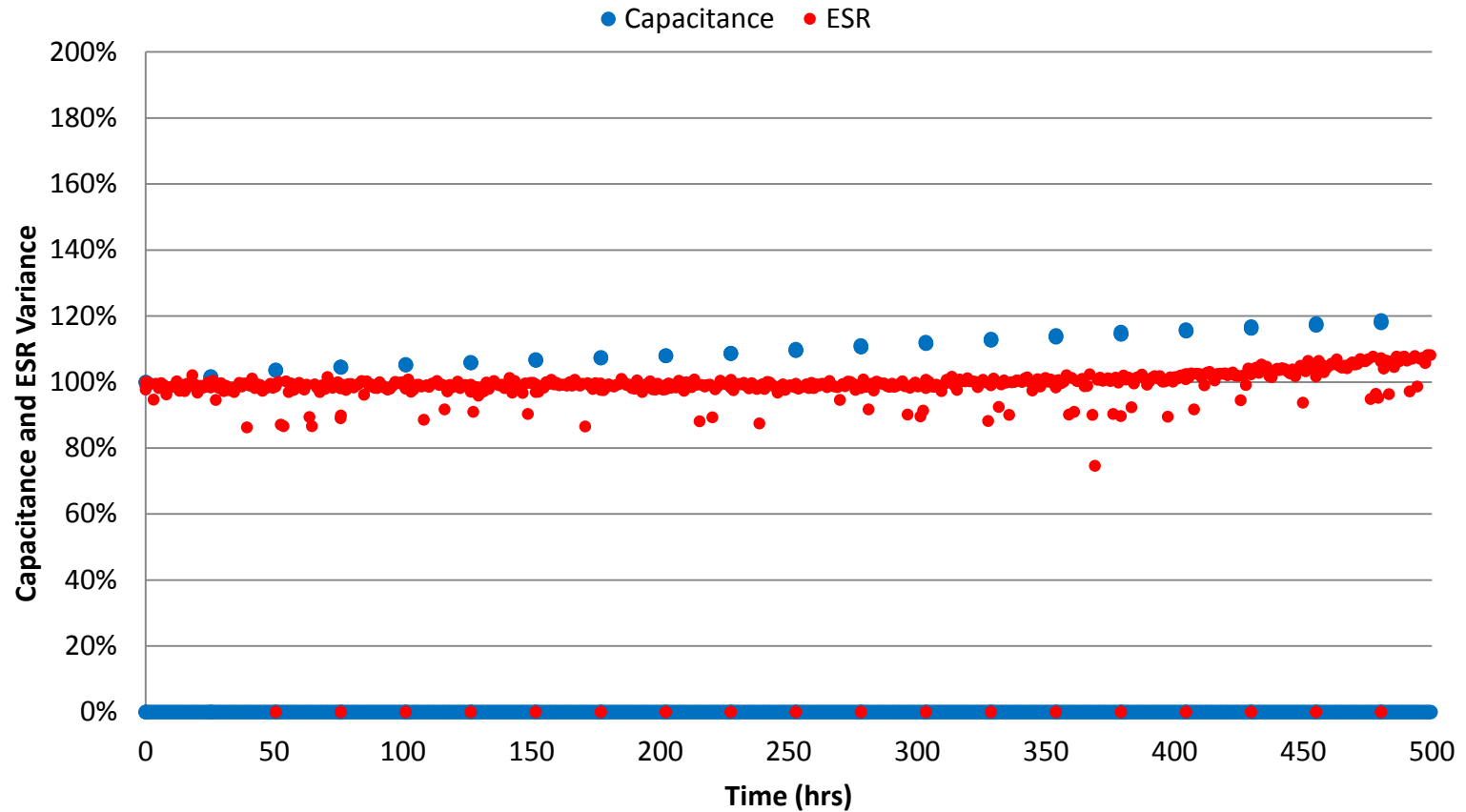
World's first and only
High Temperature
Ultracapacitor

High Frequency Ultracapacitor

Very Low Leakage Ultracapacitor

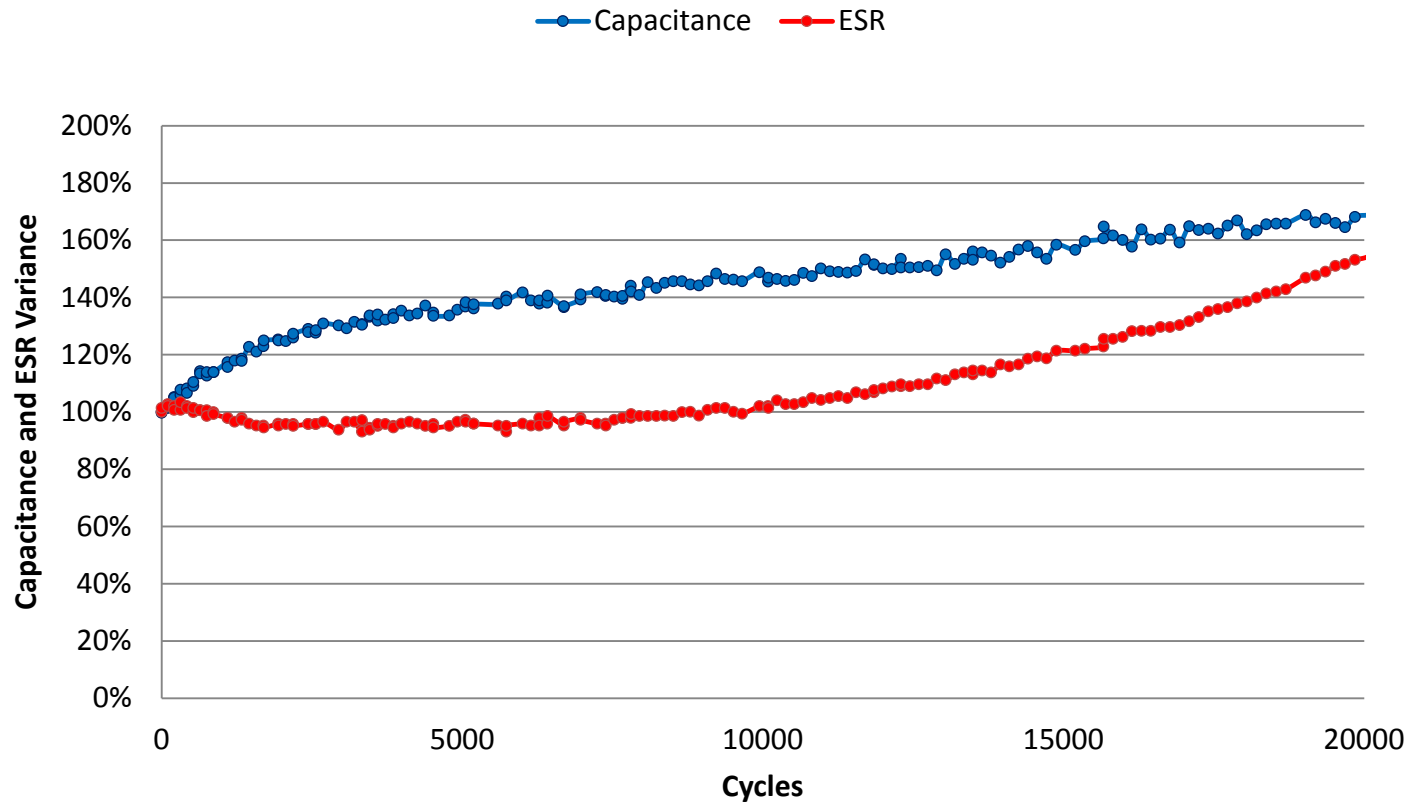


Sandia Validation: 250°C Ultracapacitor Performance Minimal Degradation after 500 hours at 250°C

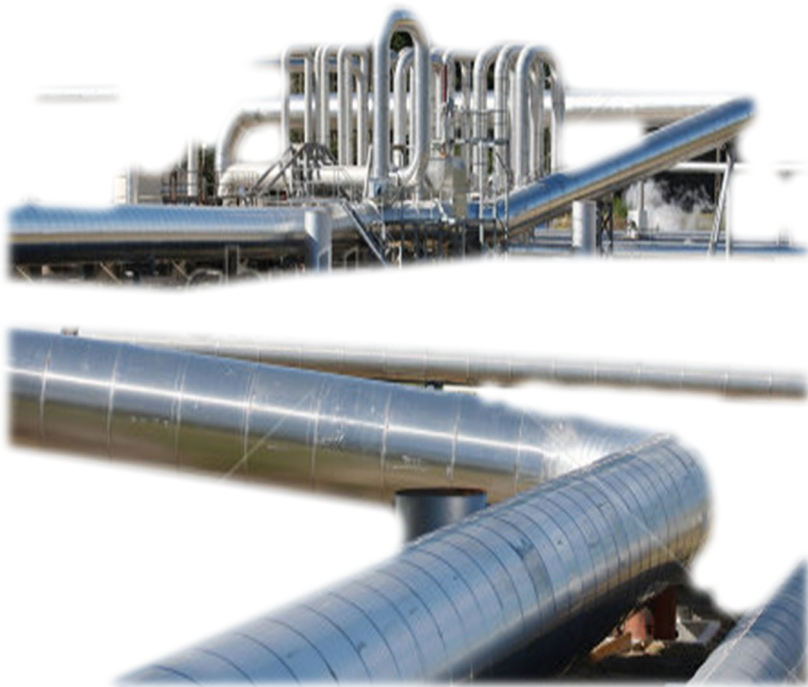


In-House Prototype: Extended Test

300°C Ultracapacitor Performance Minimal degradation after 20,000 charge discharge cycles



What Does This Mean for MDW, LWD and Geothermal Exploration and Well Development? New Unprecedented Capabilities Enabling Faster, Efficient Geothermal Exploration



- High powered logging tools, including active seismic and through casing resistivity tools
- Production logging, providing resource optimization, drawdown monitoring and tracking of fluid boundaries
- High powered EM telemetry for directional drilling, enabling fast and accurate resource exploration and development, air drilling in high loss formations
- Formation evaluation and characterization tools, including deep investigation resistivity tools



NanoramicTM
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Nanocarbons based Composite Materials for the Electronics
Industry

FASTCAP 
ULTRACAPACITORS[®]

Extreme Environment Ultracapacitors