



FastCAP Systems

2016 Technology and Product Overview (updated 7/6/16)

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Extreme Environment

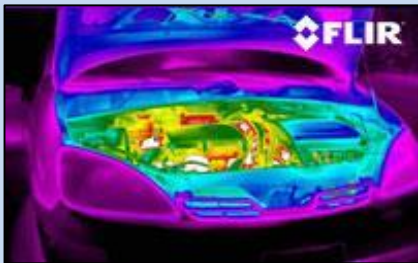


With roots in geothermal research, FastCAP has pioneered extreme environment ultracapacitor technology. Today, FastCAP is the only company with ultracapacitors capable of high temperature ($>125^{\circ}\text{C}$), low temperature ($<-40^{\circ}\text{C}$), and hermetically sealed capacitors capable of enduring the space environment. FastCAP's technology has been validated from -110°C to 250°C by Sandia National Laboratory.

FastCAP also offers capacitors ruggedized against extreme shock and vibration for energy, defense, automotive, and aerospace applications with vibration survival in excess of 20gRMS and shock survival of 500g.

FastCAP technology excels in environments where other energy storage fails.

Under-the-hood



High temperature, vibration ruggedized ultracaps extend the lifetime of lead acid and Li-Ion batteries

- Start/Stop
- Smart Alternators
- Brake Regeneration
- Electric Turbochargers
- Battery Augmentation

Oil and Gas



150°C operation with shock survivability enable high power rechargeable energy storage.

Remove Lithium batteries improving safety while eliminating storage, handling, and shipping restrictions

Defense



The only ultracapacitor technology with full military temperature range (-55°C to 125°C).

Enable high performance actuation, voltage bus stabilization, point-of-load power buffering, and enhance weapon systems (EMLAS, Railgun)

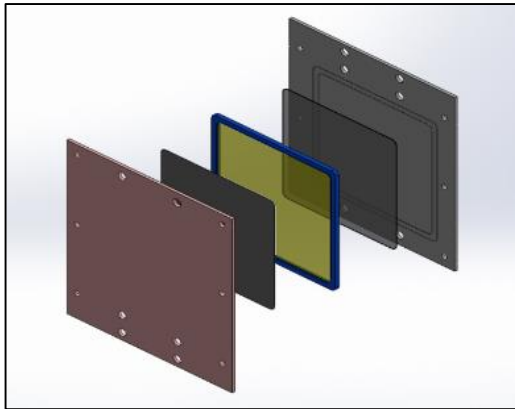
Space



Reduce battery size and weight while enabling new payloads, such as electric actuators and radar, with improved bus stabilization.

Store energy with direct sun exposure and reduced thermal regulation

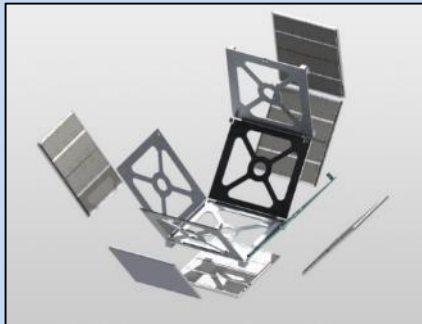
Conformal / Structural Cells



Space constrained environments often don't have the luxury for traditional large format cells. Conformal cells enable high performance energy storage in nearly any shape or configuration. **Add energy storage where it wasn't possible before.**

Create a satellite frame or car panel that safely charges and discharges with millions of lifecycles. **Structural cells combine energy storage and structural strength for extremely high energy and power density solutions.**

Small Satellites



High temperature, vibration ruggedized ultracaps extend the lifetime of lead acid and Li-Ion batteries

Enable high power long life cycle regeneration for highest efficiency gains in both hybrid and gasoline vehicles

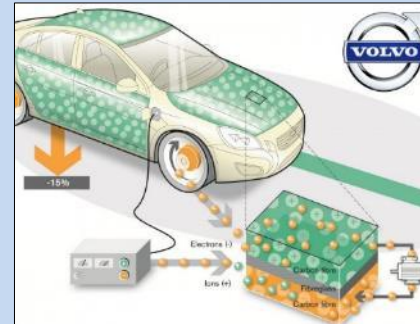
Missile Systems



Ruggedized construction and custom form factors enable superior performance over traditional batteries.

FastCAP is capable of custom modules in all shapes and sizes, e.g. flat, square, curved, toroidal

Vehicles



Vehicle frames, body panels, and component housings have the potential to serve both structural and energy storage requirements, enabling new power architectures and extending battery lifetime.

Renewable Installations



Conformal and integrated storage opens new opportunities for increased capacity, balancing, and power, and lifetime.

- Solar panel backing
- Turbine blades
- Inverter housings

High Power and Energy Density



Reaching record breaking energy and power densities allows systems to minimize size and cost. FastCAP has developed techniques and methods to optimize either energy density, power density, or both to give an **unprecedented advantage in performance** over current state of the art.

Highest Energy

18.69 Wh/L

3-10X ultracap incumbents

Highest Power

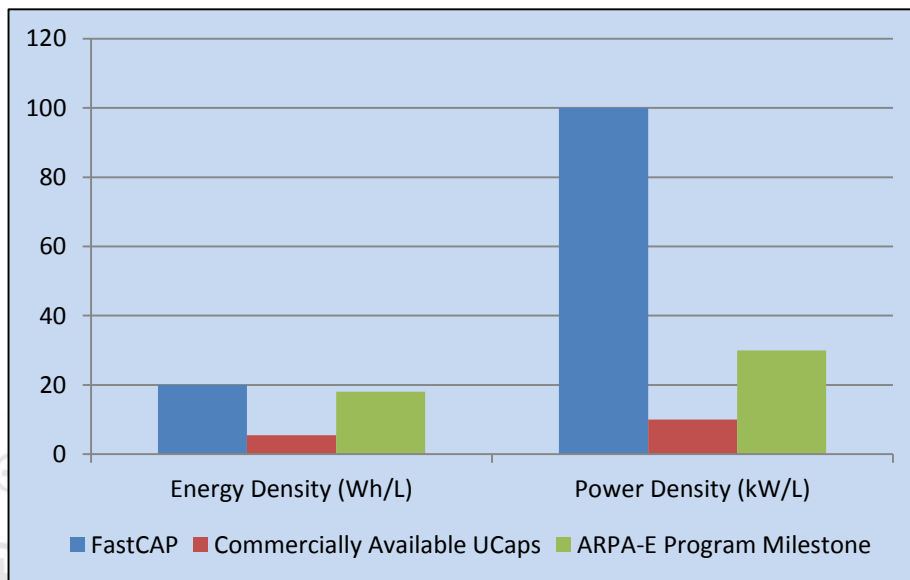
120.44 kW/L, 117.32 kW/kg

10X ultracap incumbents

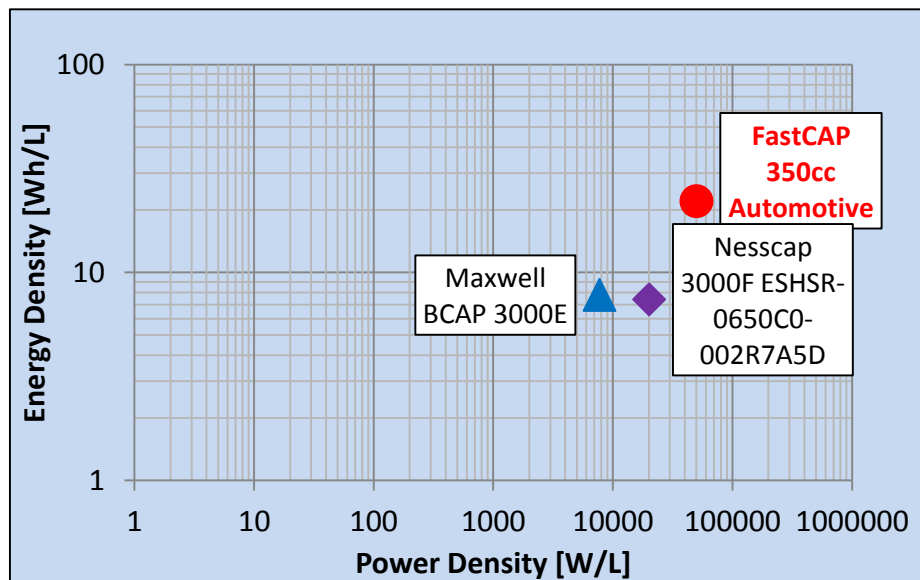
Highest Power and Energy

41.04 kW/L and 14.93 Wh/L in single cell

4X and 3X ultracap incumbents



ARPA-E Program Milestones Compared with FastCAP and Commercially Available Ultracap Performance



Large size automotive ultracapacitor performance vs. FastCAP

Specialized Applications



Specific applications call for specific technologies. FastCAP has developed an array of IP across different capacitor applications that allows customers to find the right technology to best fit the needs whether it be cost, size, or performance.

Our engineering team can design and test capacitor performance across practically all performance parameters, enabling a new level of customization. With U.S. manufacturing partners, custom modules can quickly be transitioned to full scale production models.

Improving on current technologies allows users to improve systems and further the designs to reach next level performance.

Low Leakage



FastCAP ultracapacitors have leakage into the low nanoampere scale which allow for minimum power draw from their power source.

- Energy harvesting
- IoT energy storage
- Remote sensors
- Remote communication

High Frequency



Large capacitors often suffer from a relatively poor performance for high frequency loads. With a cutoff frequency of 500 Hz and an 20-50x improvement in energy density, FastCAP capacitors can address new markets in power line buffering, power supply bypassing, and UPS support.

Our high frequency technology has been validated by Sandia National Laboratory.

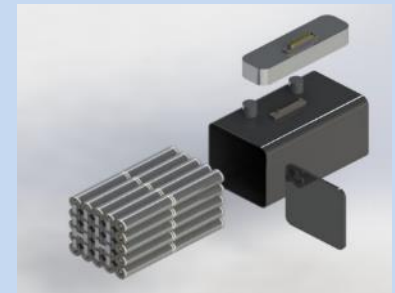
Hermetically Sealed



Hermetically sealed ultracapacitors enable space applications without large heavy support systems. This technology represents the best candidate for space grade ultracapacitors systems.

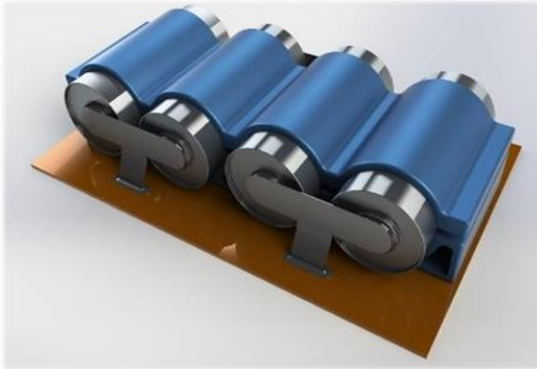
- Small Sat Radar
- Remote Sensing
- Satellite Bus Regulation

Custom Designs



FastCAP welcomes new development opportunities including hybrid modules and housings. With a full range of performance technology and testing capabilities, FastCAP is the solution to the most difficult to solve energy storage problems.

Module Engineering



FastCAP maintains a full suite of capabilities for module development and testing including a full machine shop, harsh environment test facility, and production environment. FastCAP also works closely with third party validation partners for a wide range of testing capabilities.

Power Electronics

Voltage conversion, cell balancing, cell limiting, isolated electronics, sensing, communication, logging, and conversion

Mechanical Assembly

Multi-string assemblies, conformal coating, potted systems, connectors, mechanical mounts, PCB and sensor mounts

Testing and Validation

-80° - 350°C Temperature, 60g vibration, 500g shock, life cycle testing

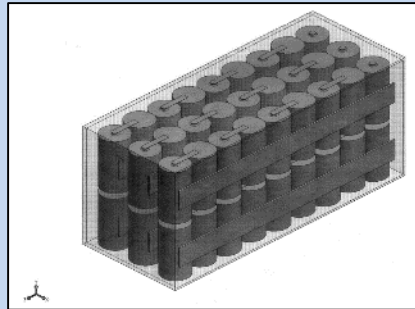
Downhole Equipment



With an expertise in down-hole energy exploration products, FastCAP is uniquely suited for downhole energy storage, power generation, and power conversion module engineering.

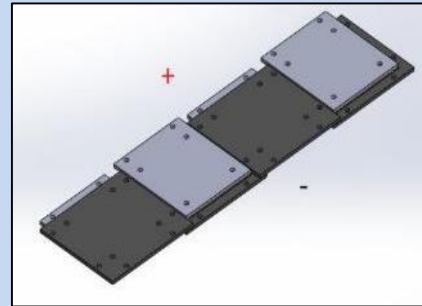
Our experience includes mud pulse power buffering, electro-magnetic telemetry amplifiers, generator power buffering, real-time clock backups, wireline logging tool, and sensing and communication applications.

Aerospace



With numerous NASA supported projects and support from companies like Lockheed, Raytheon, and General Atomics, FastCAP is a key partner in advanced Aerospace technology include fuel cell buffering, pyrobox, electric actuation and propulsion and more.

Launch Vehicles



FastCAP's experience in harsh environments applies to launch vehicles where mass, volume, and shock survival are pressing requirements.

Systems include stage separation, actuation and control, and power bus filtering.

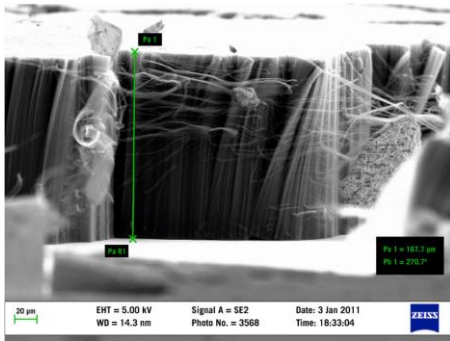
Micro-hybrids



Micro-hybrids can increase efficiency, lifetime, and performance in industrial and consumer vehicles.

Applications include start/stop modules, regenerative braking, torque assist, smart alternators, and electric turbochargers.

Nanomaterials

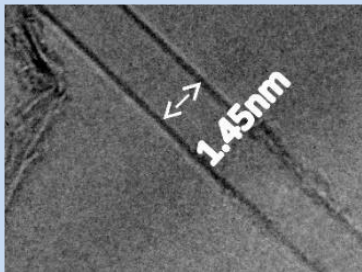


FastCAP specializes in producing vertically aligned carbon nanotubes (VA-CNTs). They possess all the material properties of typical CNTs, but every nanotube is pointing in the same direction, attached to a substrate with the CNTs oriented orthogonally to the surface.

CNT Advantage: High tensile strength and Young's modulus; Higher thermal conductivity than diamond; Higher electrical conductivity than copper; Excellent optical absorption

Why VA-CNTs: Well defined nanostructure; Safer handling than loose powders; The ordered structure of the material enables them to be used in applications where bulk powders are inadequate.

More CNT Offerings

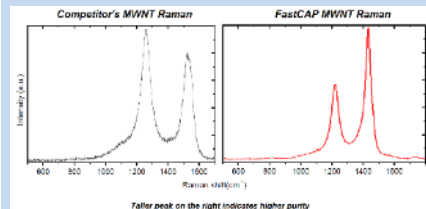


Multi-walled CNTs: Most common variety; FastCAP carries longer CNTs than most.

Double-walled CNTs: No other manufacturer consistently produces VA-DWNT.

Single-walled CNTs: Few other options for VA-SWNT.

Higher Material Purity



FastCAP's proprietary manufacturing process yields lower amorphous carbon impurities and higher crystallinity than competitors.

Characterization services available include:
TEM, SEM, TGA, Raman

Substrate Variety



Stainless Steel and Silicon are standard: inquire about aluminum, quartz, etc.

More size options than any competitor.

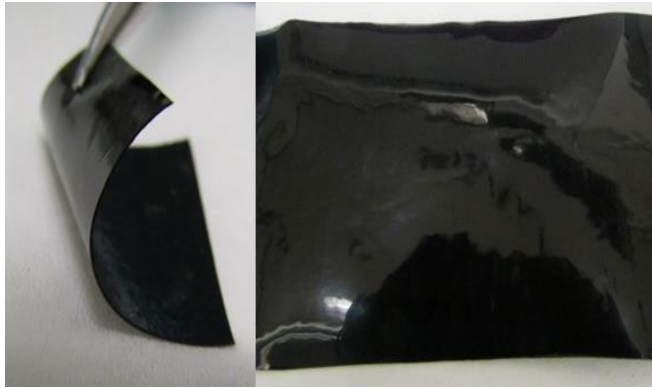
Customization Options



FastCAP can develop parts for specific applications.

Capabilities include CNTs grown on foils, plates, insulators, curved faces, large sizes, patterned arrays, double-sided CNT growth, etc.

Advanced Composites



FastCAP's carbon nano-tubes (CNTs) are some of the longest and purest on the market today. Superior purity aids in more complete dispersion while the CNTs long length creates a highly connected CNT matrix ultimately amounting to more effective and efficient material enhancement over other nanotube technology.

Researchers are just beginning to realize and integrate CNTs in new composite materials for **outstanding thermal conductivity, electrical conductivity, material strength, and composite surface area**.

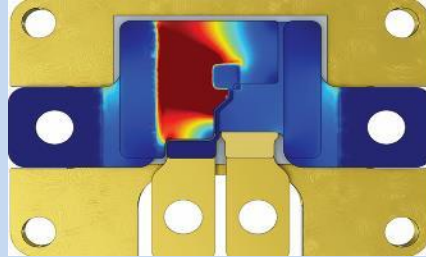
Electrical Conductivity



Conductive composites provide anti-static conductivity for improved safety in fuel tanks and can improve EMI shielding for sensitive electronics applications.

- Antistatic coatings
- Fuel tank composites
- Electronics EMI shielding
- Doped metals and polymers

Thermal Conductivity



Heat dissipation is critical for nearly all high power applications. FastCAP CNTs have been proven to increase thermal conductivity while inferior CNTs can actually decrease thermal conductivity.

- Heat sinks
- Improved solder
- Thermal shields

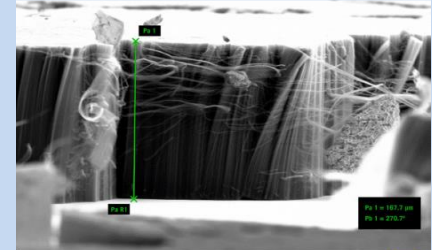
Material Strength



Many applications have taken advantage of the enhanced tensile strength and toughness provided by CNT composites.

- Mechanical housings
- Drill bits
- Turbine blades
- Gears
- Rotors and flywheels

Energy Storage



CNT electrodes increase surface area, thermal, and electric conduction thereby creating a battery or capacitor with greater energy storage, life time, and power capabilities. Such technology can also be applied to photovoltaics and thermovoltaics while simultaneously improving panel strength.



Ultracapacitors for Sale

Model Name	Case	Capacitance (F)	Voltage (V)	ESR (mΩ)	Max. Temp. (°C)	Mass (kg)	Volume (mL)
EE100-350	D	370	2.0	7.4	100	0.110	55
EE125-350	D	360	1.5	6.6	125	0.110	55
EE150-350	D	345	1.0	5.8	150	0.110	55
EE100-35	AA	38	2.0	17.3	100	0.021	7.9
EE125-35	AA	36	1.5	16.7	125	0.021	7.9
EE150-35	AA	33	1.0	16.4	150	0.021	7.9

Contact us at **contact@fastcapsystems.com** or visit our website at **www.fastcapsystems.com** for pricing, ordering, and additional technical information on our ultracapacitor products.



Nanotubes for Sale

Single-Wall Nanotubes

Substrate Material	Substrate Size	VA-CNT Length (μm)	Price (USD)	Part Number
Si	1x1 cm	10-50	***	SISW1S
		100-500	***	SISW1L
	2x2 cm	10-50	***	SISW2S
		100-500	***	SISW2L
	3x3 cm	10-50	***	SISW3S
		100-500	***	SISW3L
SS	1x1 cm	10-50	***	SSSW1S
		100-500	***	SSSW1L
	2x2 cm	10-50	***	SSSW2S
		100-500	***	SSSW2L
	3x3 cm	10-50	***	SSSW3S
		100-500	***	SSSW3L

Multi-Wall Nanotubes

Substrate Material	Substrate Size	VA-CNT Length (μm)	Price (USD)	Part Number
Si	1x1 cm	10-50	***	SIMW1S
		100-500	***	SIMW1L
	2x2 cm	10-50	***	SIMW2S
		100-500	***	SIMW2L
	3x3 cm	10-50	***	SIMW3S
		100-500	***	SIMW3L
	2" wafer	10-50	***	SIMW2DS
		100-500	***	SIMW2DL
	SS	1x1 cm	10-50	SIMW1S
		100-500	***	SIMW1L
		2x2 cm	10-50	SIMW2S
		100-500	***	SIMW2L
		3x3 cm	10-50	SIMW3S
		100-500	***	SIMW3L
	5x5 cm	10-50	***	SIMW5S
		100-500	***	SIMW5L

Double-Wall Nanotubes

Substrate Material	Substrate Size	VA-CNT Length (μm)	Price (USD)	Part Number
Si	1x1 cm	10-50	***	SIDW1S
		100-500	***	SIDW1L
	2x2 cm	10-50	***	SIDW2S
		100-500	***	SIDW2L
	3x3 cm	10-50	***	SIDW3S
		100-500	***	SIDW3L
SS	1x1 cm	10-50	***	SSDW1S
		100-500	***	SSDW1L
	2x2 cm	10-50	***	SSDW2S
		100-500	***	SSDW2L
	3x3 cm	10-50	***	SSDW3S
		100-500	***	SSDW3L

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Project Engagement



- Government contract partnerships
- Capacitor design and manufacturing
- Hybrid module development
- Energy storage design and simulation

FastCAP specializes in rapid turn-around for highly customized energy storage solutions. We've developed concepts and prototypes across a range of different applications for both government and commercial partners.

Located in Boston's Innovation District, FastCAP has access to a wide array of technology and resources to aid in engineering and concept development.

We welcome new development opportunities, whether it's a brand new idea or a modification of an existing product.

For information on project engagement, please contact us at **contact@fastcapsystems.com**