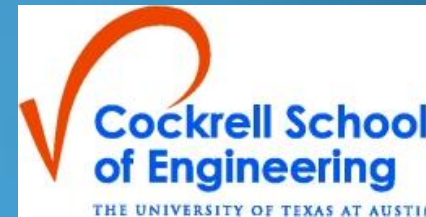


The CMG Ultracapacitor

Josh Mueller
Matt Saunders
Andrew Tilstra

The University of Texas at Austin
McCombs School of Business
Cockrell School of Engineering

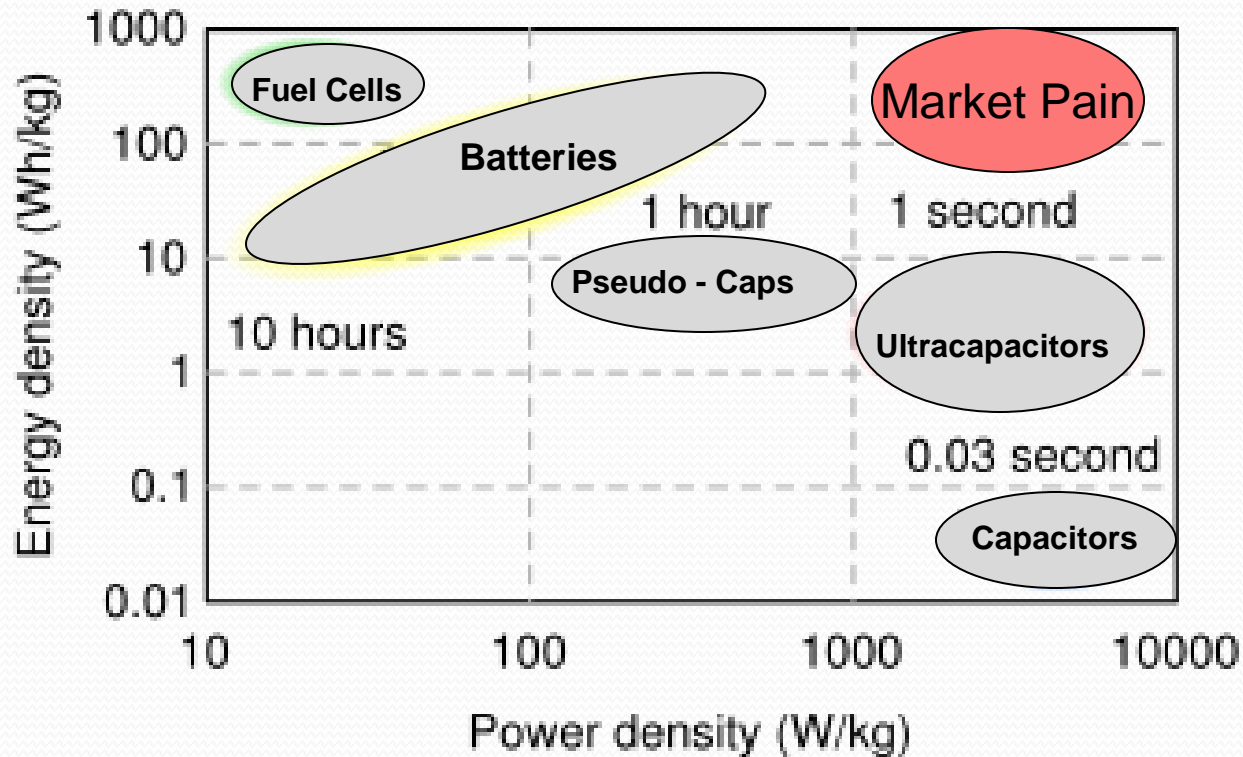


Demand for Better Energy Storage

- **#1 Problem for Clean Energy Businesses:** (Director of Economic Development for Austin Chamber of Commerce)
- **Holy Grail for Energy Companies:** (Director at Austin Technology Incubator)



Energy Storage Today



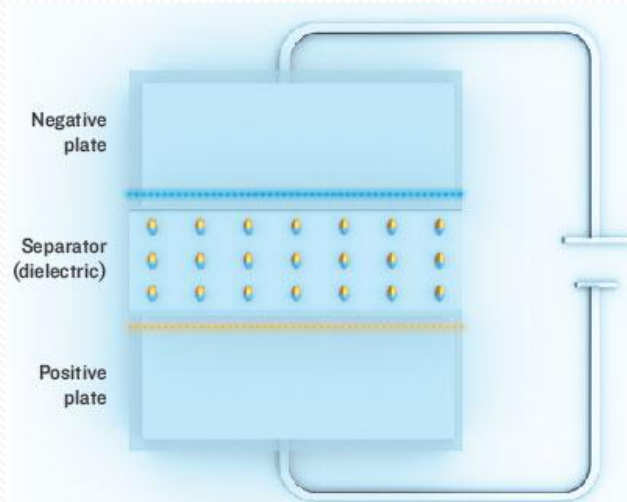
Energy Density = The ability to store energy
Power Density = The ability to release energy

What is a Capacitor?

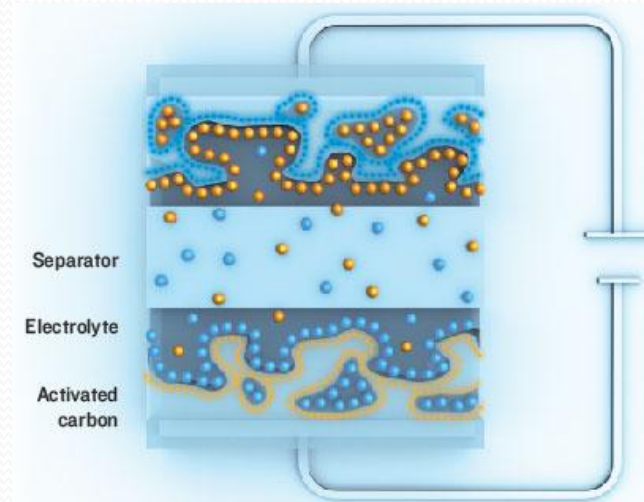


What is a Capacitor?

Capacitor



Ultracapacitor



Ultracapacitors vs. Batteries

	Ultracapacitors	Batteries
Life Cycle	~ 500,000 charges	~5000 charges
Charge/Discharge Time	Seconds	Minutes to Hours
Power	~ 10,000 W/Kg	~ 1,000 W/Kg
Maintenance	Little to none	Replacement needed
Energy Storage	~5 Wh/Kg	~75 Wh/Kg

Source: President of an engineering firm that researches ultracapacitor design.

Ultracapacitor Market

- **Size***

- \$350M per year globally
- Expected to grow 15.3% per year



- **Limited Improvement Over Last Few Decades:** (VP of Maxwell, Top U.S. Producer of U-Caps)

- **Interest**

- Maxwell (Ultracapacitor manufacturer with \$57M in Revenue)
 - Energy storage
 - Energy Release
 - Cost

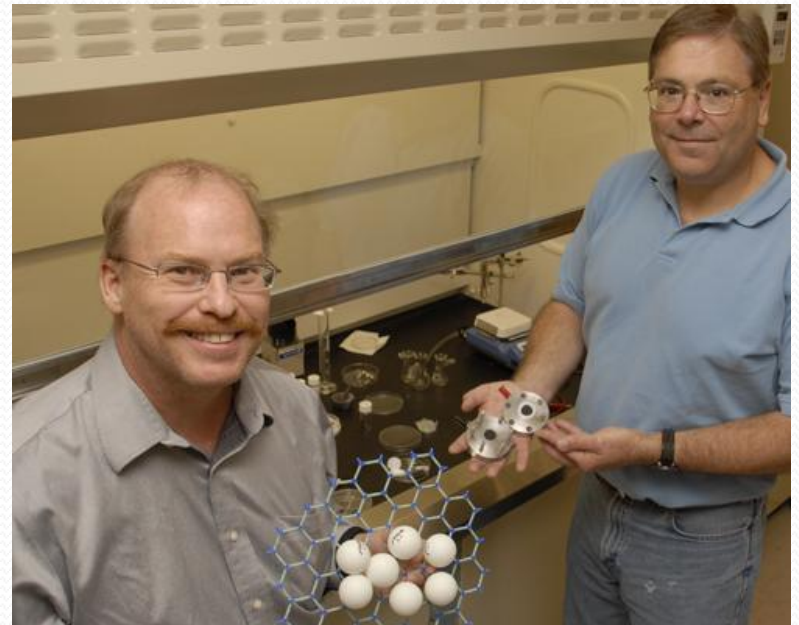
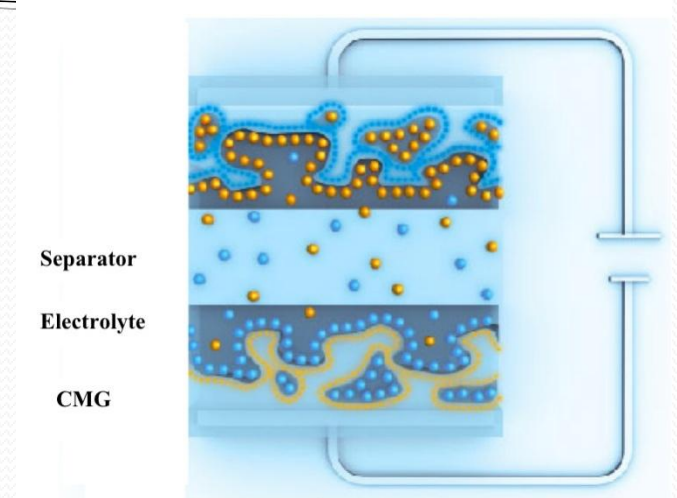


Possible Solution:

CMG
Ultracapacitor

What is the CMG Ultracapacitor?

- Developed by Dr. Ruoff and Meryl Stoller
- Graphene - 1 atom thick sheet of carbon
- Graphene replaces Activated Carbon

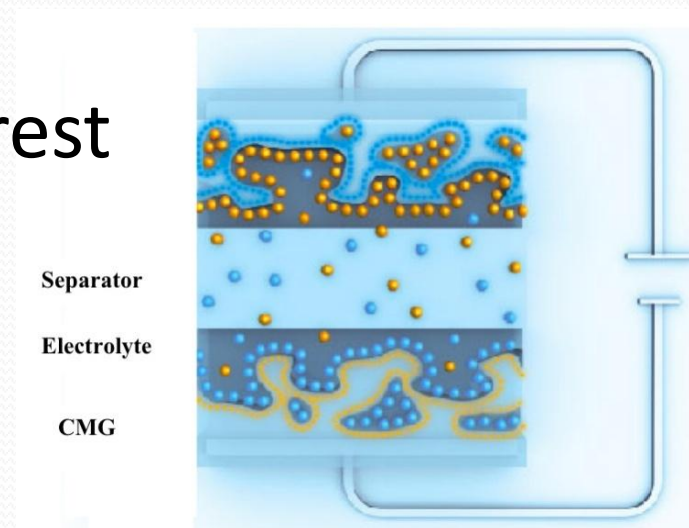


1 Kilogram is...

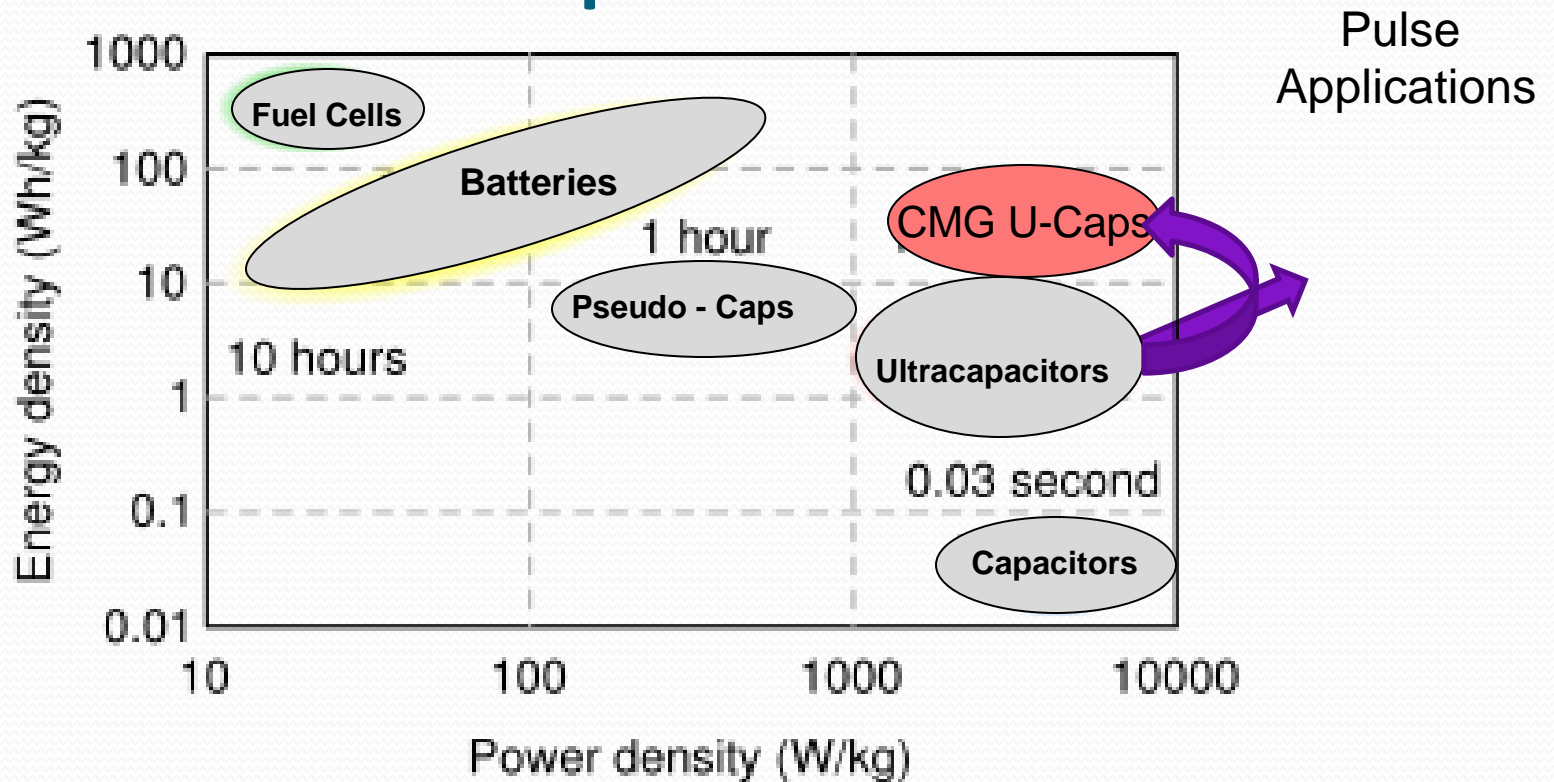


The Potential of CMG Ultracapacitor?

- 2-3x storage possible
- Preliminary testing on par with industry
- 50% improvement reasonable
 - Industry breakthrough
 - Maxwell has expressed interest



Competition

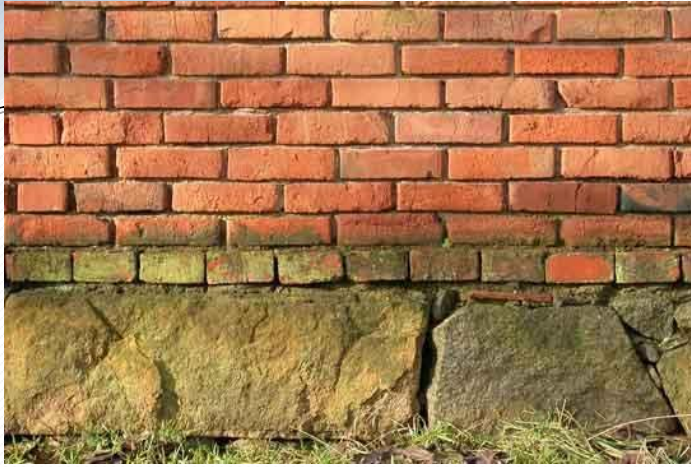


Energy Density = The ability to store energy
Power Density = The ability to release energy

Intellectual Property

- Status
 - US Patent Pending
 - International Patents in Process
- Basic Landscape
 - Freedom to operate
- Long-term Strategy
 - Patent additional applications and production process
- Barriers
 - Available resources to obtain & defend patents





Barriers to Entry

- Technology Risk
- Graphene has never been mass produced
- High cost and learning curve of manufacturing
- Solution: Licensing over producing

Potential Customers

Leading Ultracapacitor Manufacturers



- Maxwell Technologies (USA)



- NESS (South Korea)



- Okamura Laboratories (Japan)



- EPCOS (Japan)

Value

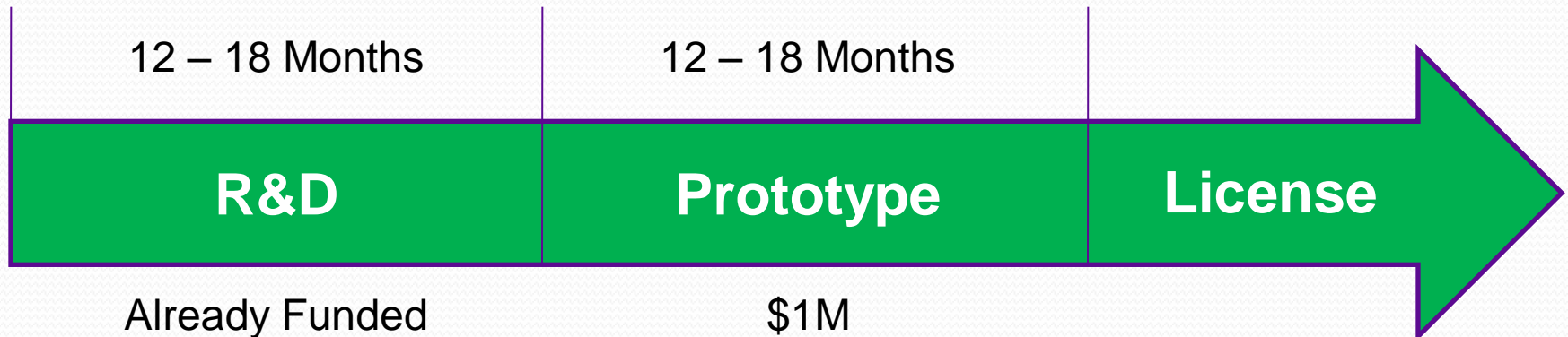
% of Maxwell Product Line	Annual License Revenue
5%	140K
50%	1.4M
100%	2.8M

- Maxwell Annual Revenue: \$57M
- License Fee: 5% of revenue

Recommendation

- Continue to develop technology

Timeline:



- Move forward based on magnitude of improvement
 - 50% or more improvement at a reasonable cost:
Move forward



Q&A

Increased Energy Storage	Approximate Energy Density	Potential Applications	Market Interest	Value Added to Customer	Available Incentives	Potential Return (9 Years)	Recommendation
No Change	~10 Wh/Kg	Small consumer electronics, Regenerative braking in large hybrid vehicles	None. No improvement	None	None	\$0	End research
1.5X	~15 Wh/Kg	Small consumer electronics, regenerative braking in large and possibly smaller hybrid vehicles	Moderate	~10% Increase in Revenue	City Emerging Technology Initiative (Just P.R.), Research Grants	5% Licensing Fee (Half of increased revenue): 6.7 Million	Attempt to license technology to current manufacturers
2X-5X	~50Wh/Kg	Breadth Unknown, but thought that many new applications would emerge	High	~20% Increase in Revenue	Tax abatements	10% Licensing Fee (Half of increased revenue); 15 Million	Still attempt to license technology to current manufacturers. However; with a larger improvement, there is more room to negotiate for non-exclusive license and higher licensing fee
10X	~100Wh/Kg	Completely Replace Batteries. Could be used to meet almost any energy storage need	Very High	~100% Increase in Revenue	Tax abatements, Texas Enterprise Fund, Texas Ignition Fund	Return would be exponentially higher, but such an improvement is not feasible. Ultracapacitors will never replace batteries	Start company, invest any money necessary in production and creating of manufacturing infrastructure

Potential Primary Markets

- Automotive
 - In conjunction with batteries in electric and hybrid cars to extend battery life
 - Toyota Supra HV-R 24 hour endurance race
 - beat the 2nd place non-hybrid finisher by more than 19 laps.
- Portable Consumer Electronics
 - Cap-XX ultracapacitor for Nokia for a cell phone camera flash
- Military Helicoptors
- Industrial Applications – fuel cell forklifts