HIGH ENERGY DENSITY SUPERCAPACITORS FOR SPACE APPLICATIONS:

A Leap Forward In Space Exploration Energy Systems

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Spin off from EPFL September 2022

EPFL Empa Materials Science and Technology

Facilities LIMNO, EPFL & EMPA

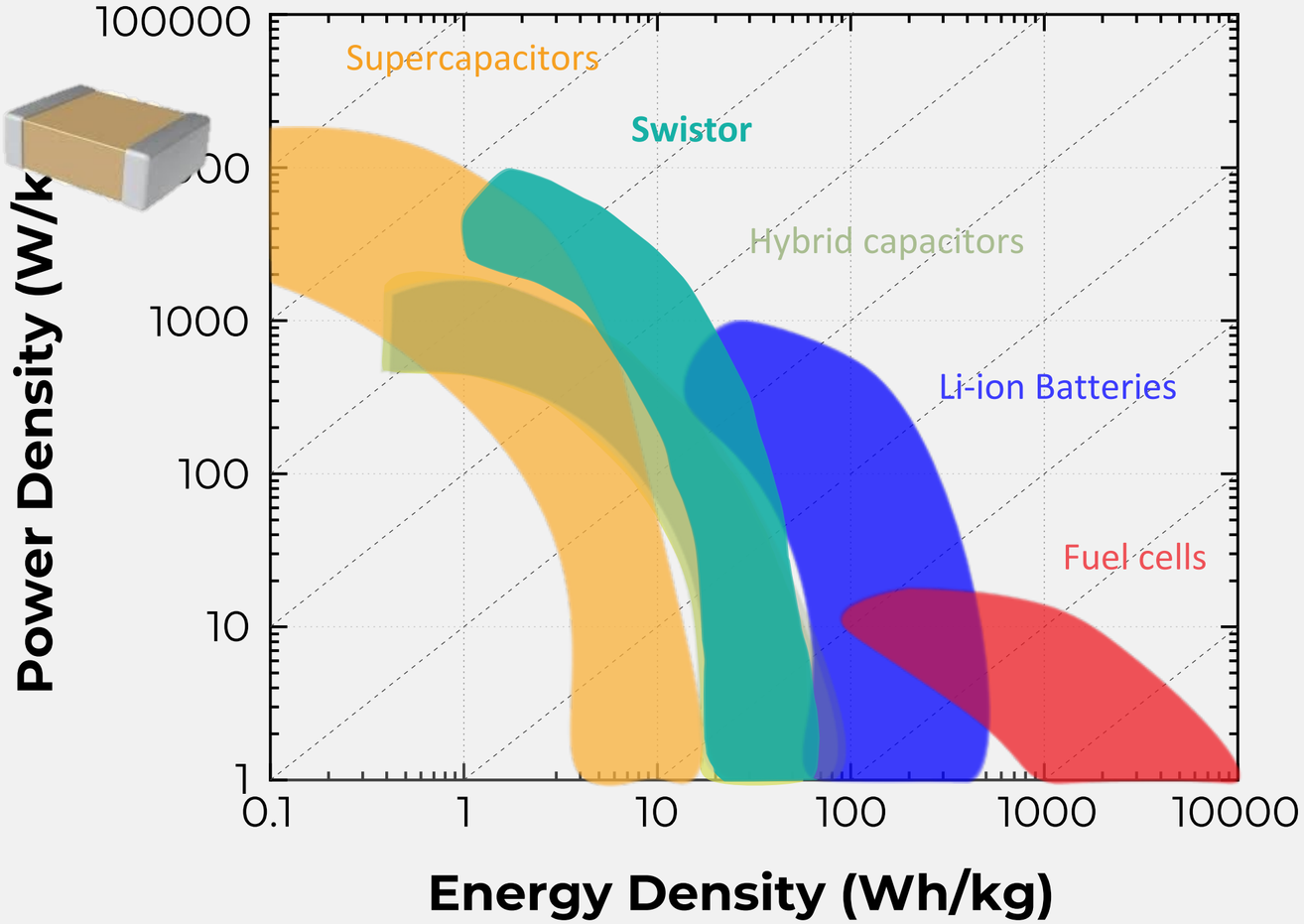
CMI, EPFL

Powering Tomorrow:

Global Trends:
High Power Density & Better Integration

“High-energy high-power supercapacitors for hybrid energy systems or power applications”

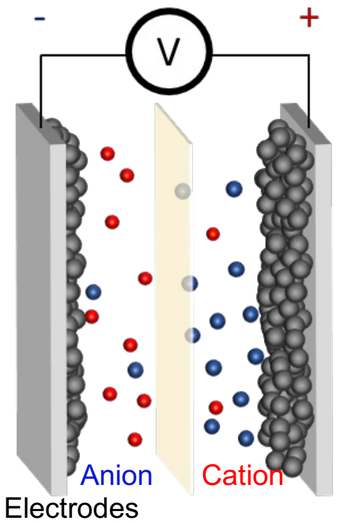
High Energy Technologies Come at the Cost of Power



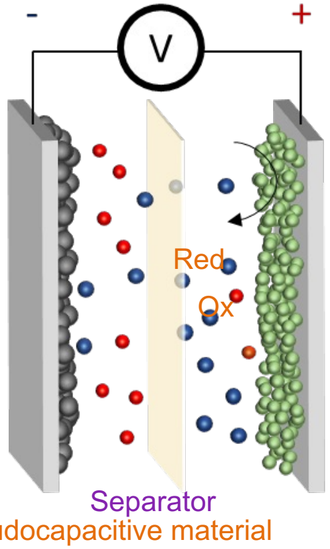
We propose integrated modules of complementary solutions for efficient electronics systems.

ENERGY STORAGE: High Power vs High Energy

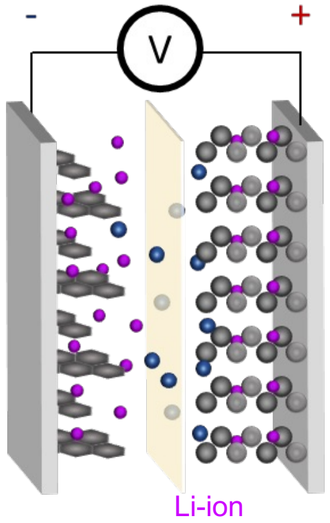
SUPERCAPACITOR: EDLC



HYBRID CAPACITOR

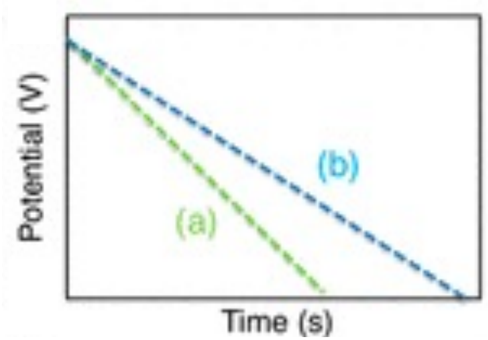


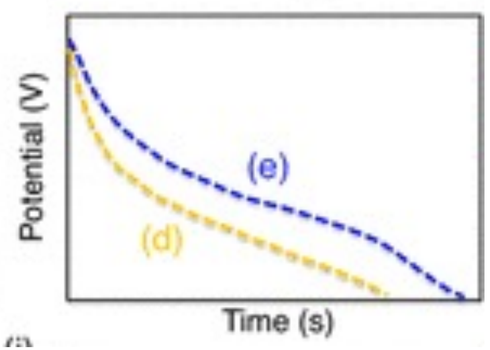
FARADAIC TYPE

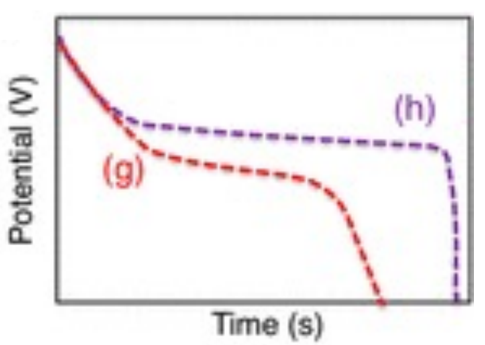


High Cycle Life

POWER





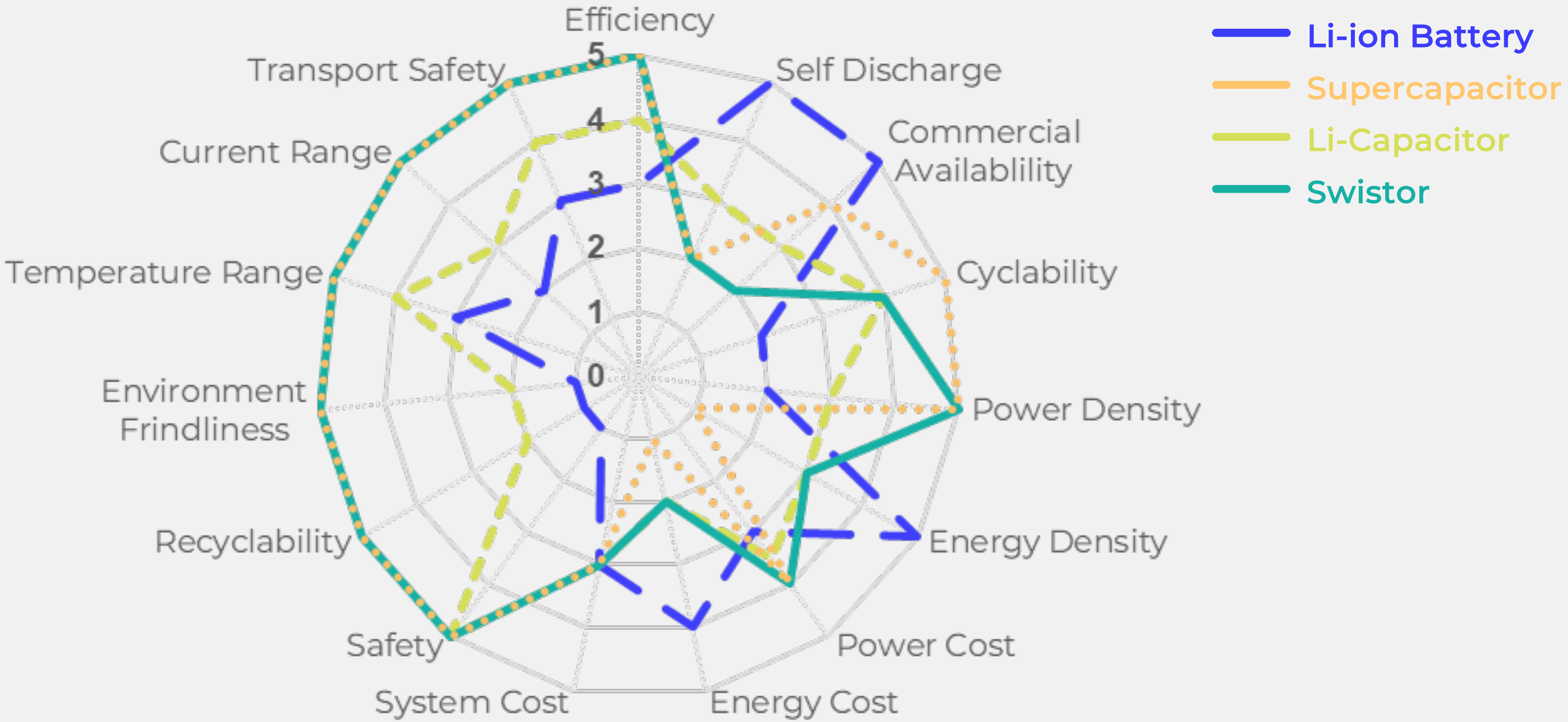


Low Cycle Life

ENERGY

Gogotsi, Y., & Penner, R. M. (2018), *ACS Nano, 12*(3), 2081-2083

Energy Storage Technologies Trade-off



NEXT GENERATION ENERGY STORAGE

Based on Hybrid Supercapacitors

60 Wh/kg

Record High Energy Density, NO Lithium.

High Power
20 kW/kg

Long Life
60’000

Eco friendly

TECHNOLOGICAL ADVANTAGES

High Energy Density without critical raw materials

Nanostructured carbon based materials and redox pseudocapacitance

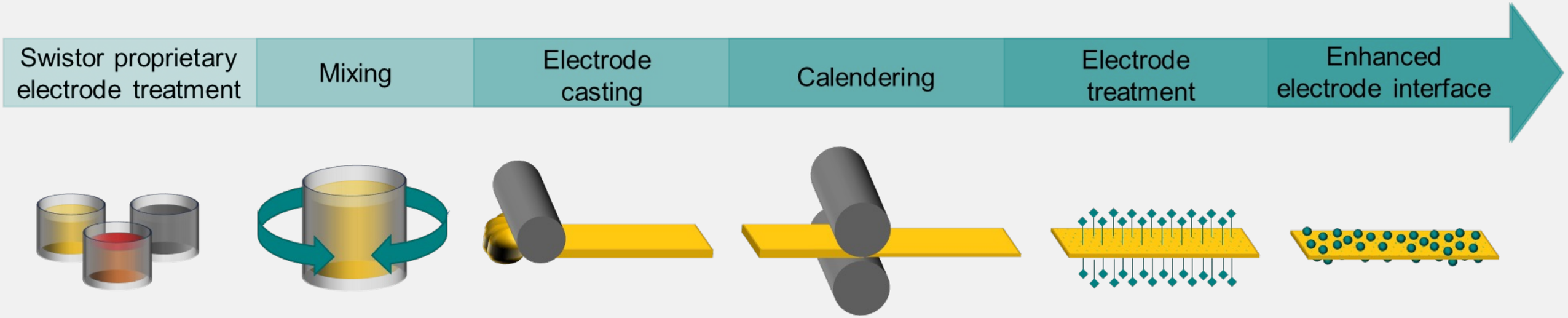
Safer low vapor pressure electrolytes

High rated voltage
High temperature stability

High Power

Conductive and stable materials

FABRICATION PROCESS

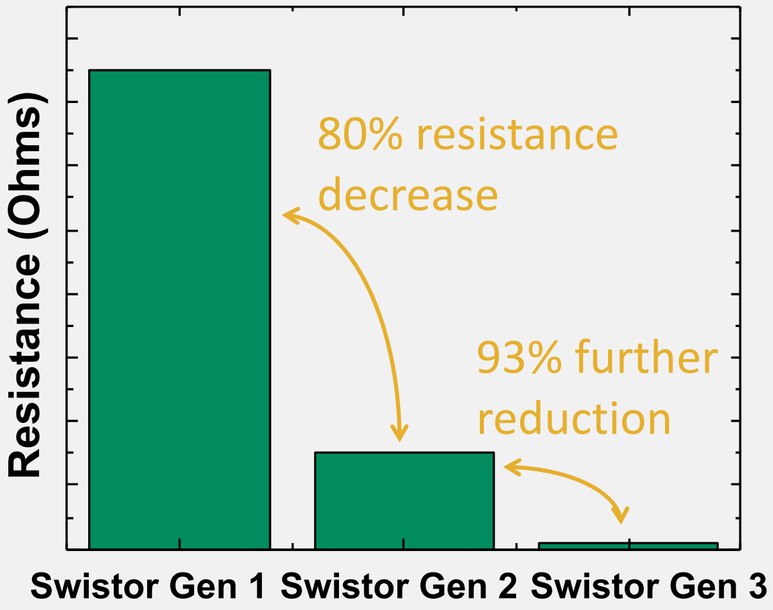


Electrolyte Compatibility **High Conductivity Electrodes** **Improved Interfaces**

CELL DESIGN

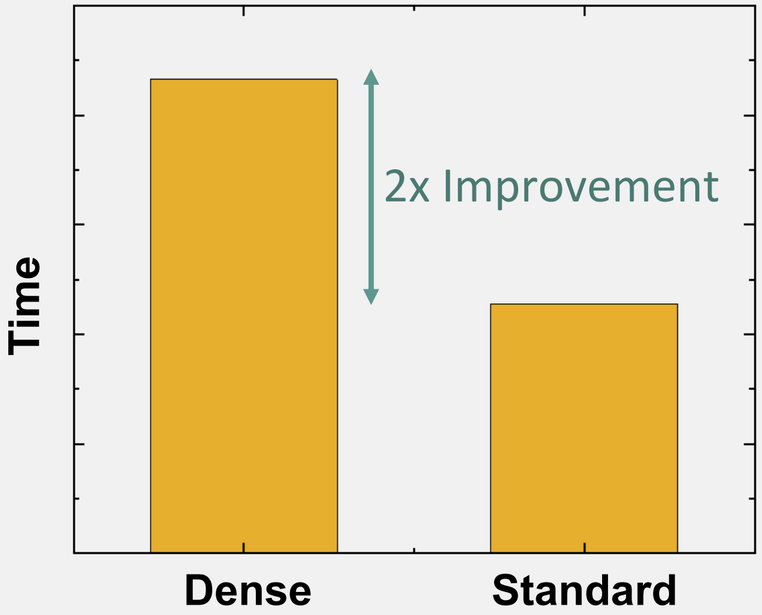
Electrode optimization

Resistance Optimization

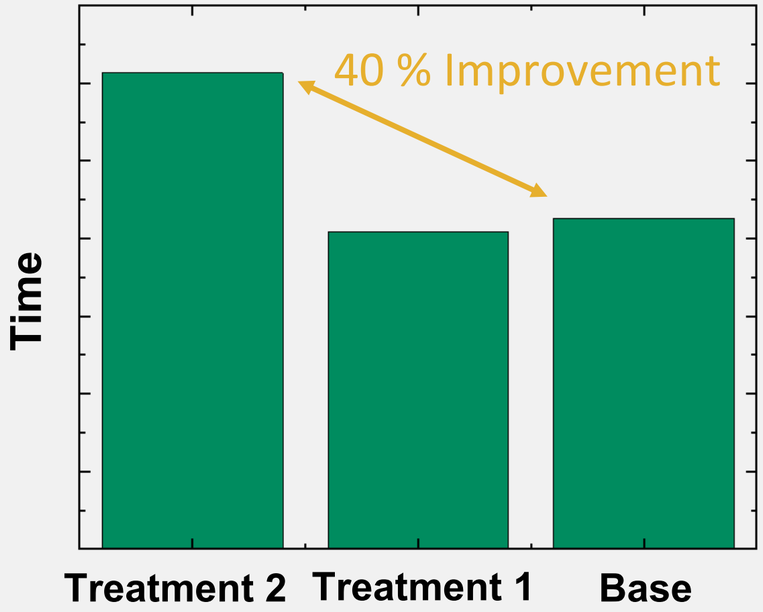


Self-Discharge Optimization

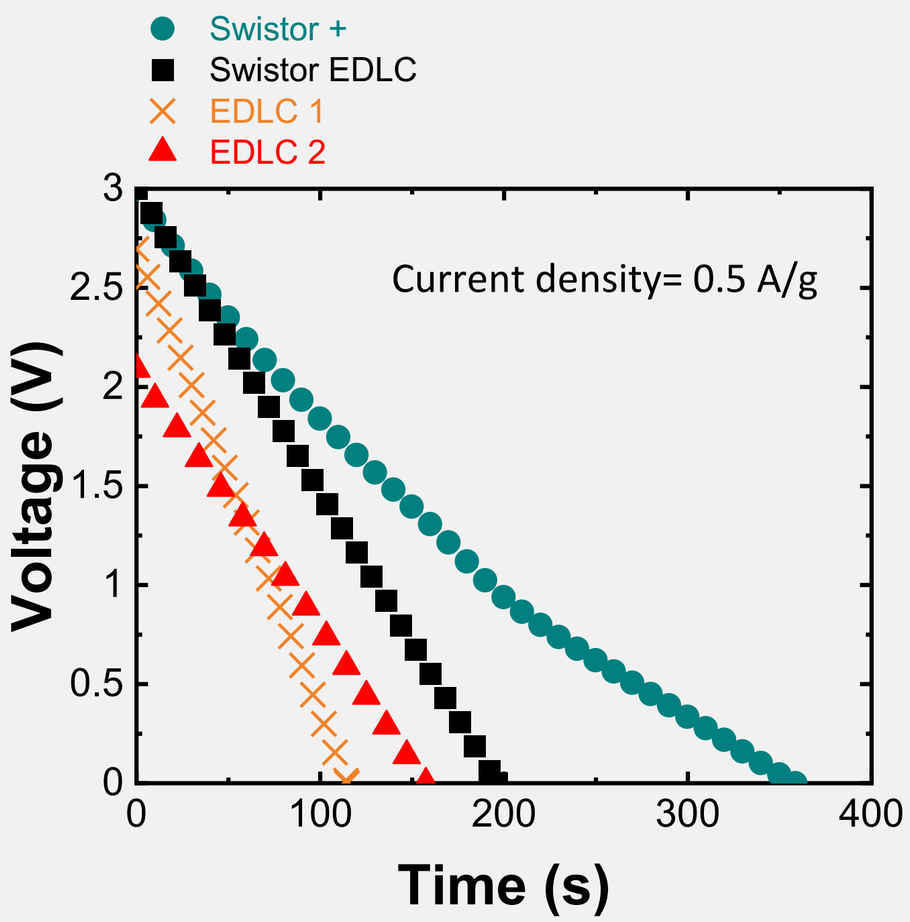
Densification

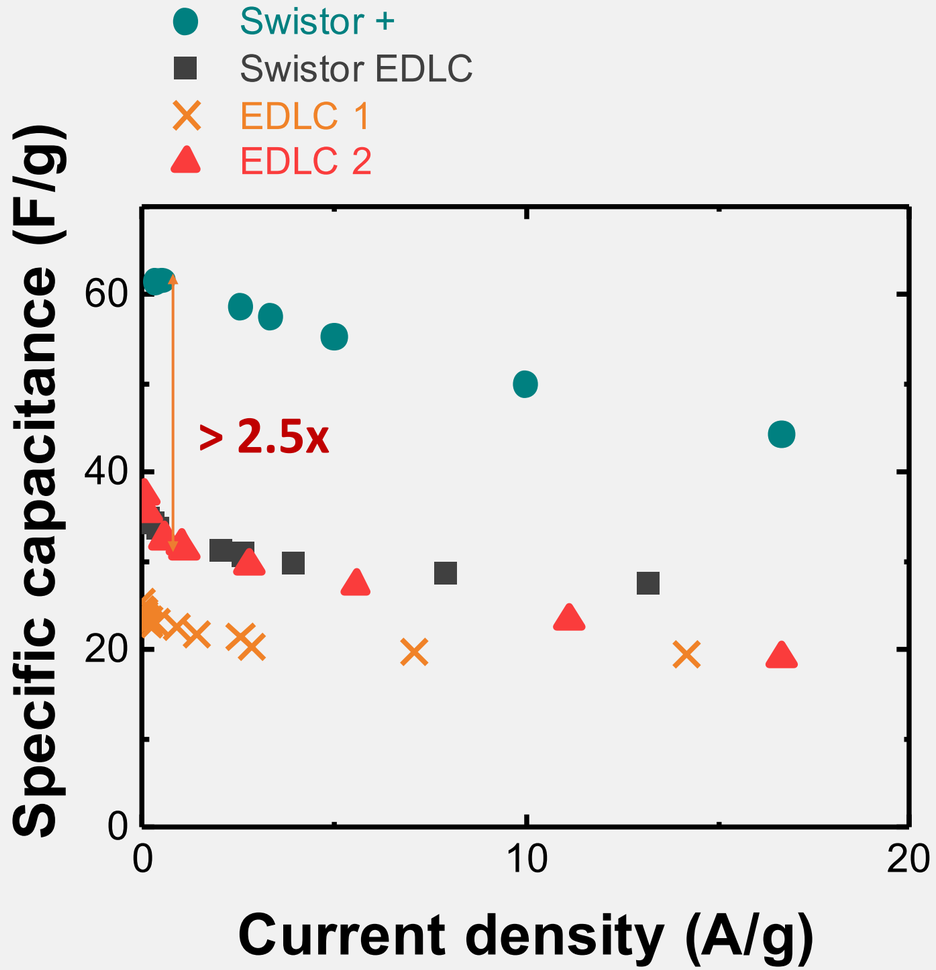


Material Interface Optimization

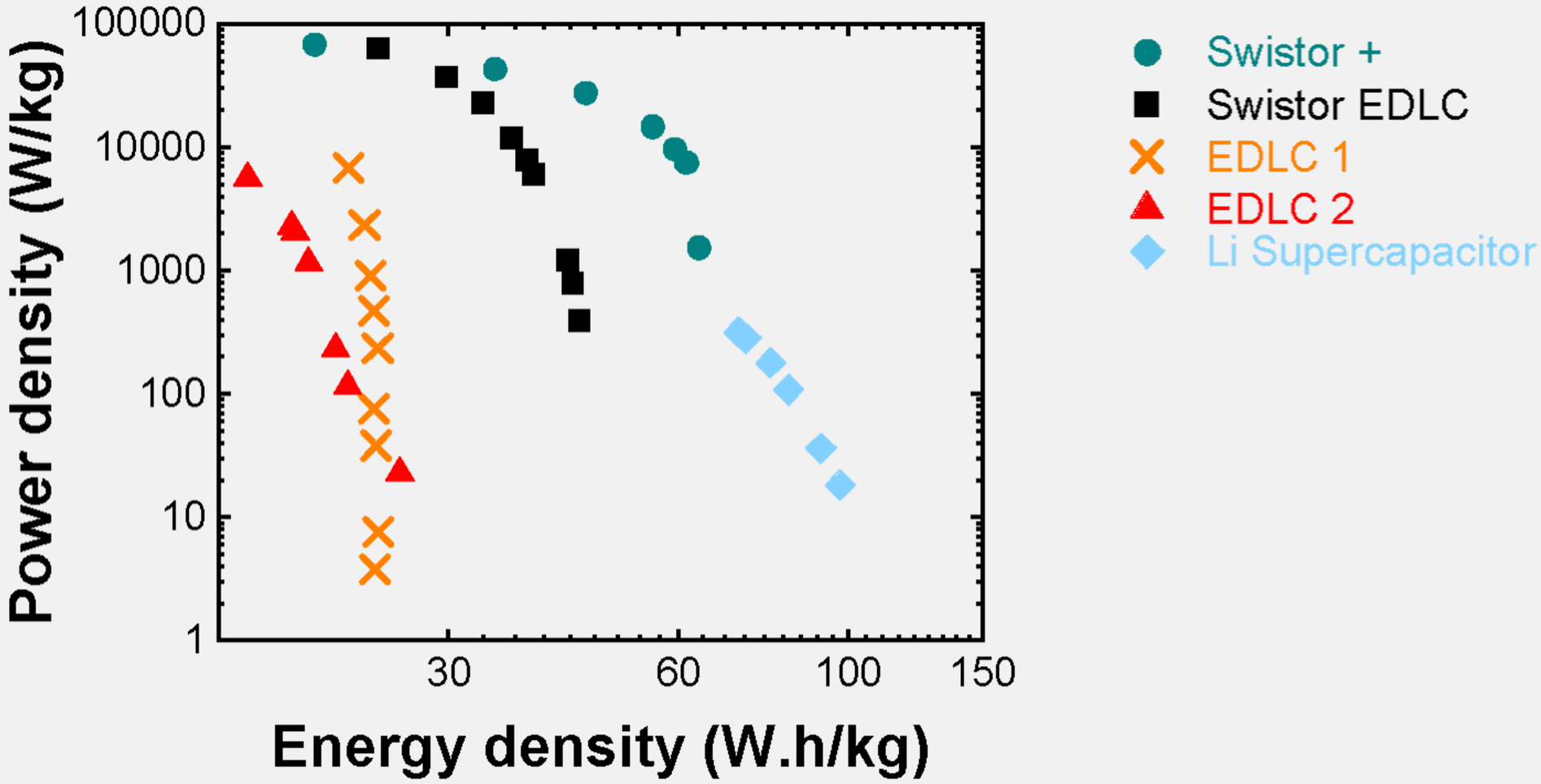


Electrochemical Performance





High Energy Density while Maintaining High Power



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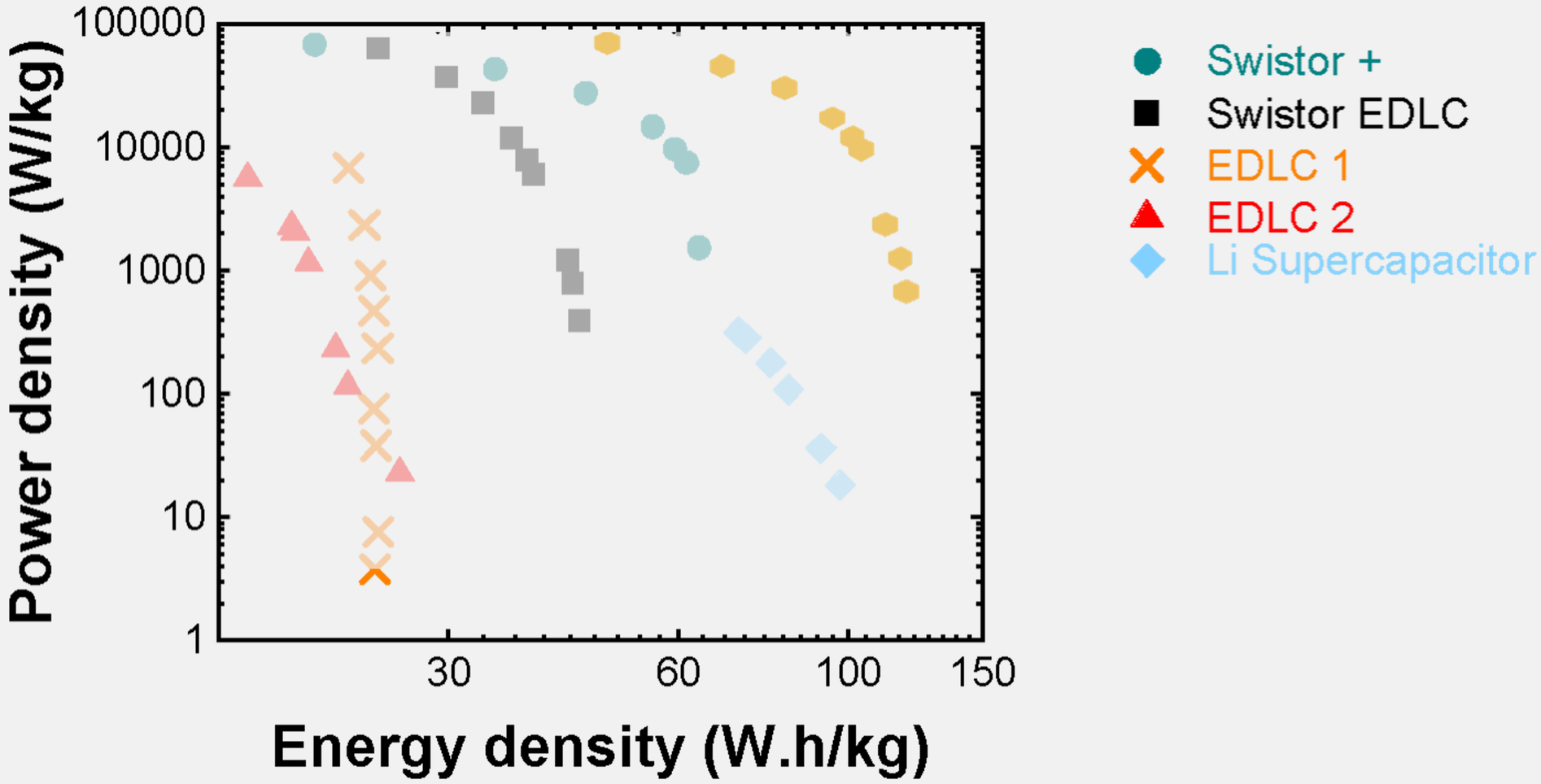
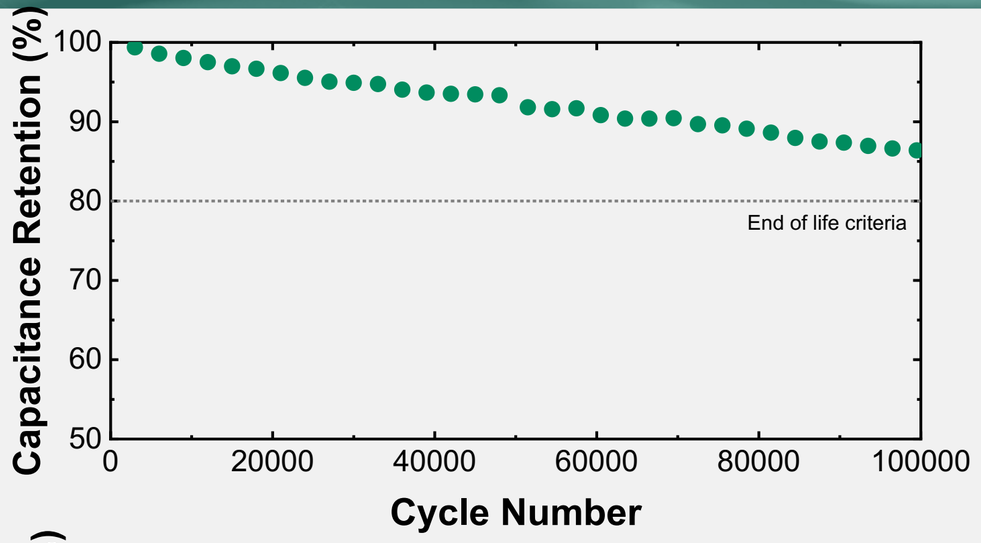
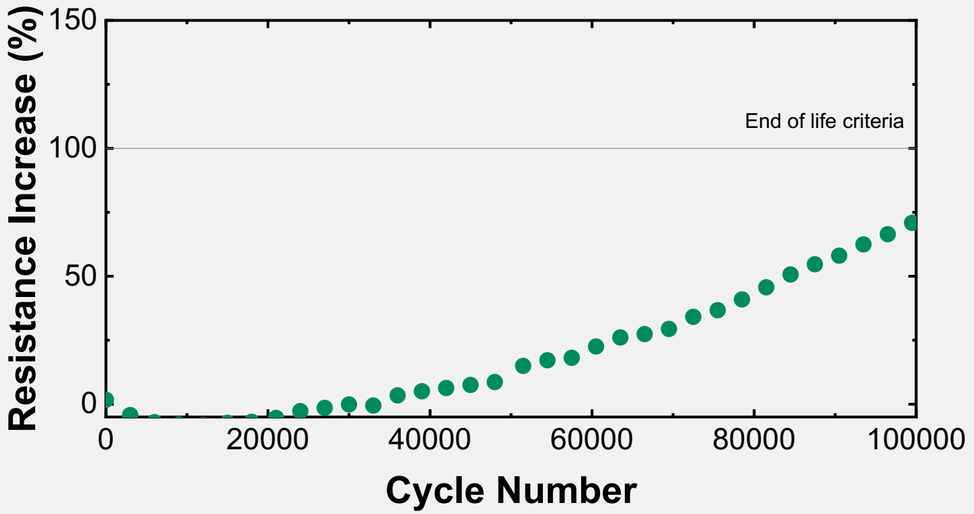


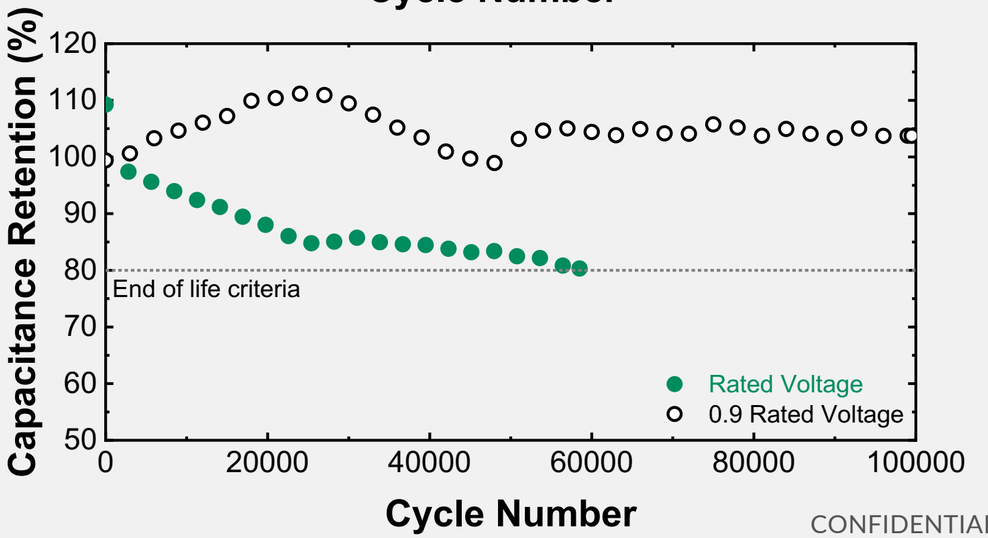
High Energy has an Impact on Cycle Life

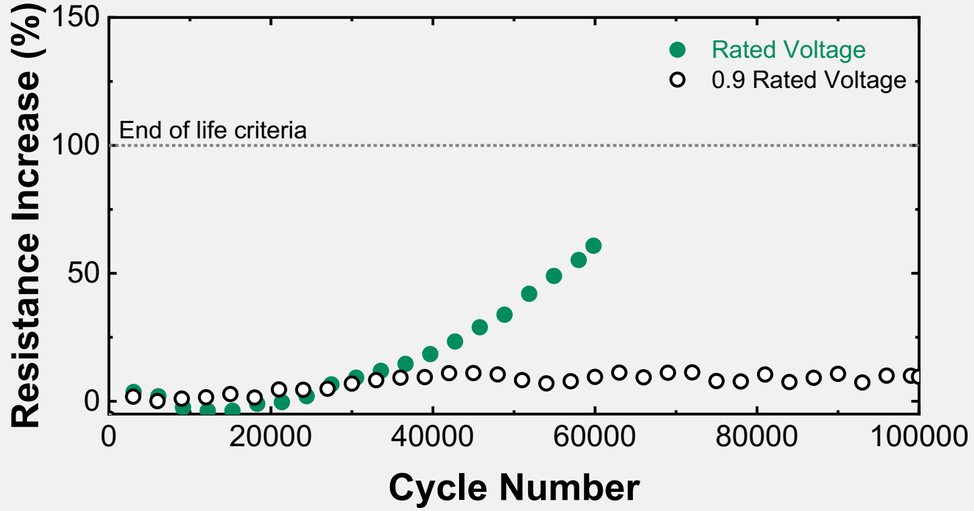
EDLC





High Energy



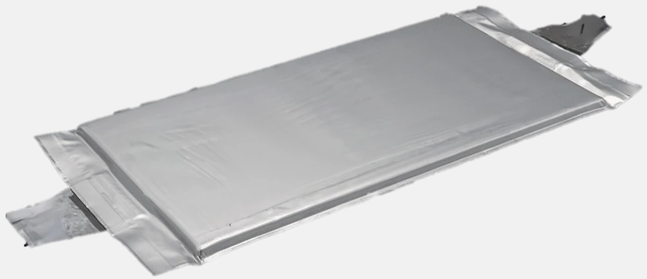


Cycling Assesment

Capacitor Type	Cycling Voltage	Minimun Voltage	Cycles	Capacitance Retained	Resistance Increased
Swistor +	3.3V	1.8V	60’000	80%	57%
Swistor +	3V	1.8V	100’000	99%	5%
Swistor +	3.3V	0V	On-going		
Swistor +	3V	0V	On-going		
Swistor EDLC	3.3V	1.8V	100’000	96%	60%
Swistor EDLC	3V	1.8V	100’000	99%	4%
Swistor EDLC	3.3V	0V	100’000	89%	100%
Swistor EDLC	3V	0V	50’000	100%	-5%

PRODUCT SPECIFICATIONS FOR POUCH CELL 2024

Parameter	Swistor High Energy	Units
Rated voltage	3.3	V
Maximum voltage	3.63	V
Capacitance	5	F
ESR	0.05	Ω
Power	**30**	W
Minimum charging current	50	µA
Endurance	50'000	cycles



L= 2 cm
l = 3 cm
Thickness< 250 µm

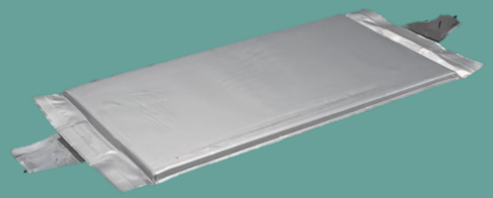
Preliminary specs
Under development

TECHNOLOGY ROADMAP

2026 — **50 F** — 0.01 Ohm, 50k lifetime

Cylindrical cell

2025 — **5 F** — 0.05 Ohm, 50k lifetime



Pouch cell

2023 — **1 F** — 2 Ohm, 50k lifetime

Coin cell

Wh/kg

100

Powering Tomorrow: Ultra-High Power Devices

for Efficient Electronics

and Renewable Energy Storage

UNLOCK THE FULL POWER OF YOUR DEVICES

SOLAR IoT MONITORS

- Battery-less systems
- Lifetime > 10 years

ROBOTICS

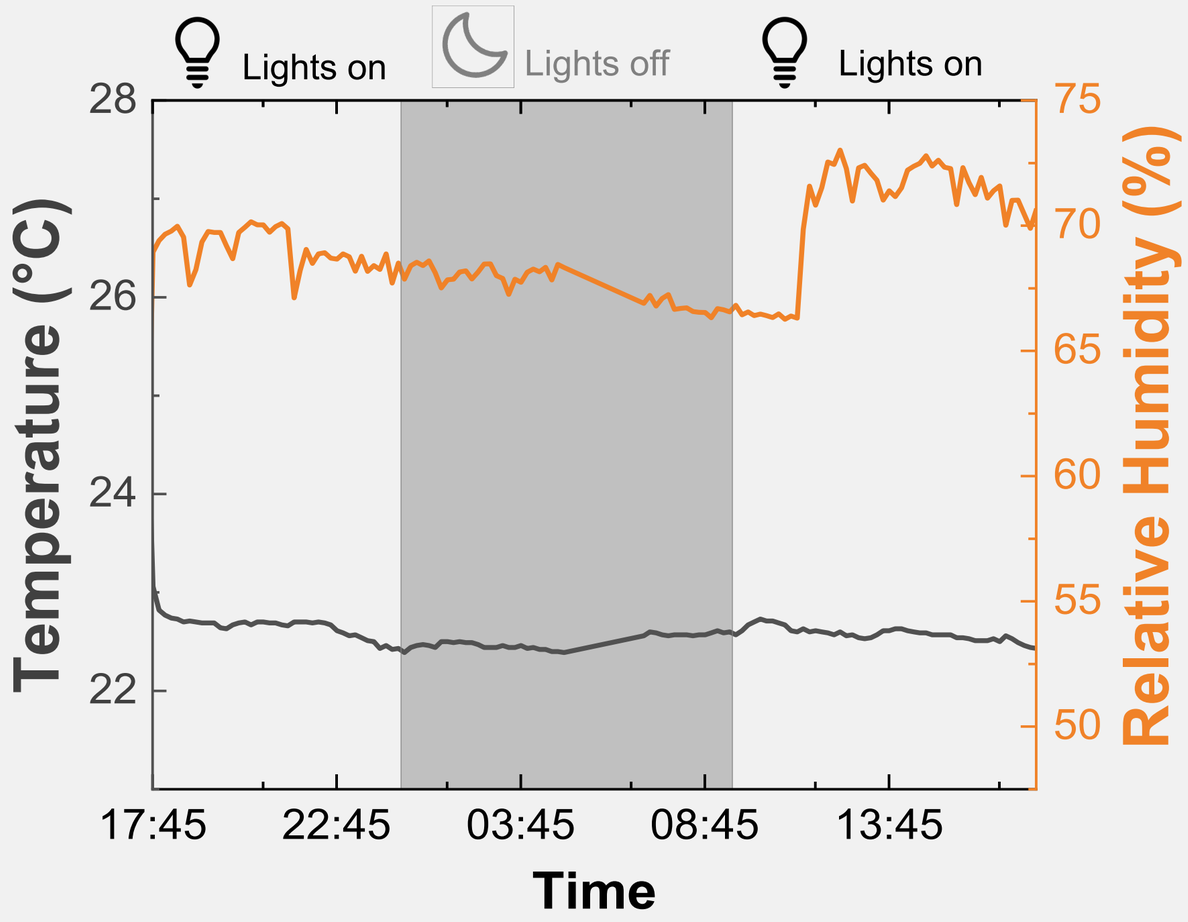
EXOSKELLETONS and EXOPROSTHESIS

- Increase peak power x 5
- Improved autonomy and lifetime

Enable Long Lasting Autonomous IoT Devices

Field Test Autonomous Sensor powered by solar cells and Swistor Supercapacitor indoors

Never Change the Battery!

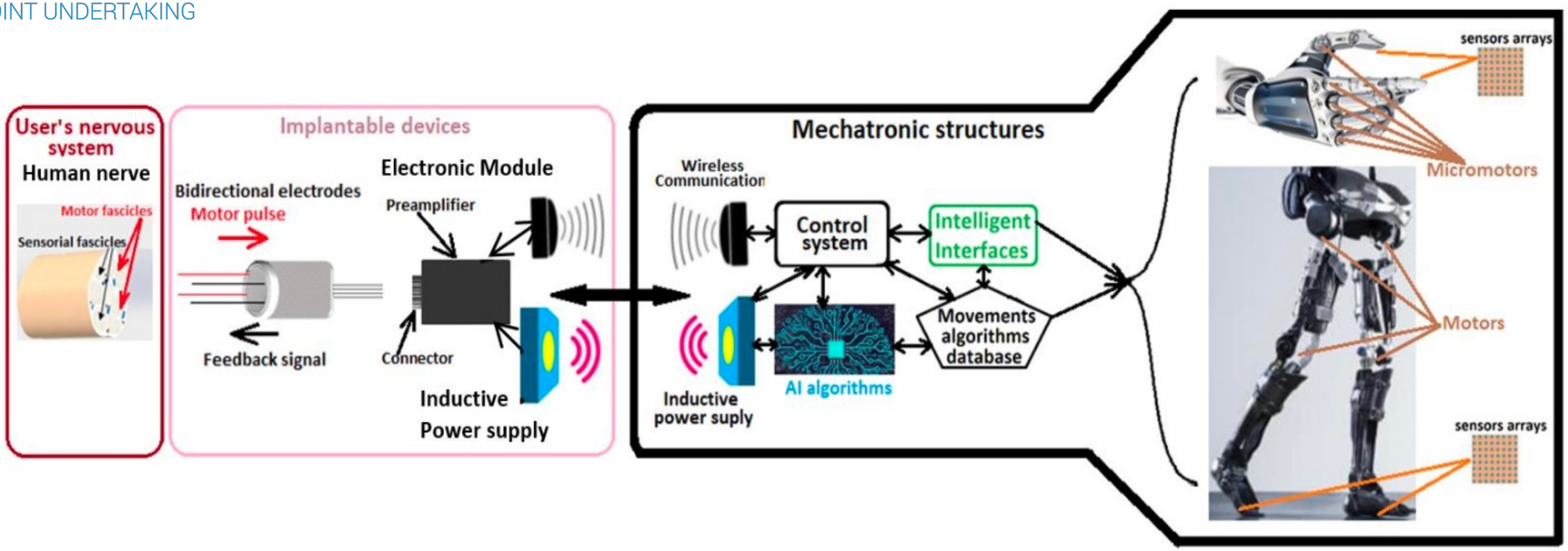


Hybrid supercapacitors
1 F
3.3 V
-20 to 80 °C

R&D MEDICAL APPLICATION

Batteryless Implantable Systems and Peak Shaving for Exoskeletons and Exoprosthesis

KEY DIGITAL
TECHNOLOGIES
JOINT UNDERTAKING



SPACE APPLICATIONS

Provide critical support for fluctuating power demands and enhancing operational efficiency

GEO SATELITES

- Power Bus voltage regulation
- High-power radar supply for small-satellite earth-observation missions
- Collision avoidance

LAUNCHERS

- Delivery of peak current for ignition
- Pyrotechnic separation mechanisms during launch phase.
- Electrical thrust vector control
- Release mechanisms: used to deploy equipment such as solar panels

CONCLUSIONS

Redox-enhanced supercapacitor

- Achieve High Energy density Supercapacitors **60 Wh/kg**
- Reached High Power density **20kW/kg**
- Demonstrated life time of **60’000** cycles at **3.3 V**

Facilitate more efficient hybrid power supplies, optimizing overall mission effectiveness and payload efficiency.

ReCHARGE THE FUTURE!

Fast & Clean Economy!