Prototype Machine for Coating Stabilized Lithium Metal Powder

Team #16 ME/ #18 ECE
Sponsor: General Capacitors LLC (Harry Chen)
Advisor: Dr. Shih, Dr. Zheng, & Dr. Frank
Instructor: Dr.Gupta & Dr. Helzer
Team Members:

Marcos Leon	John Magner
Vannesa Palomo	John Shaw
Maria Sanchez	Benjamin Tinsley

Overview of Project

- Goal and Motivation
- Background
- Current Methods
- Final Design Chosen
- Breakdown of Components
- Procurement
- Budget
- Schedule
- Initial Testing

Goal and Motivation

- General Capacitors desires a machine for coating anodes with Stabilized Lithium Metal Powder.
- Our sponsor is General Capacitors Inc.
    - Dr. Zheng, founder and chief scientist of General Capacitors, is our main technical advisor.
- The coating of anodes with SLMP will increase the capacity and energy density of batteries and supercapacitors.

Image 1: Completed SLMP coated battery.

Background

- Stabilized Lithium Metal Powder (or simply SLMP)
  - Particle size: 30-60 Microns
- We expect for our machine to coat battery electrodes with a uniform layer of SLMP increasing the batteries capacity by 5 to 15%.

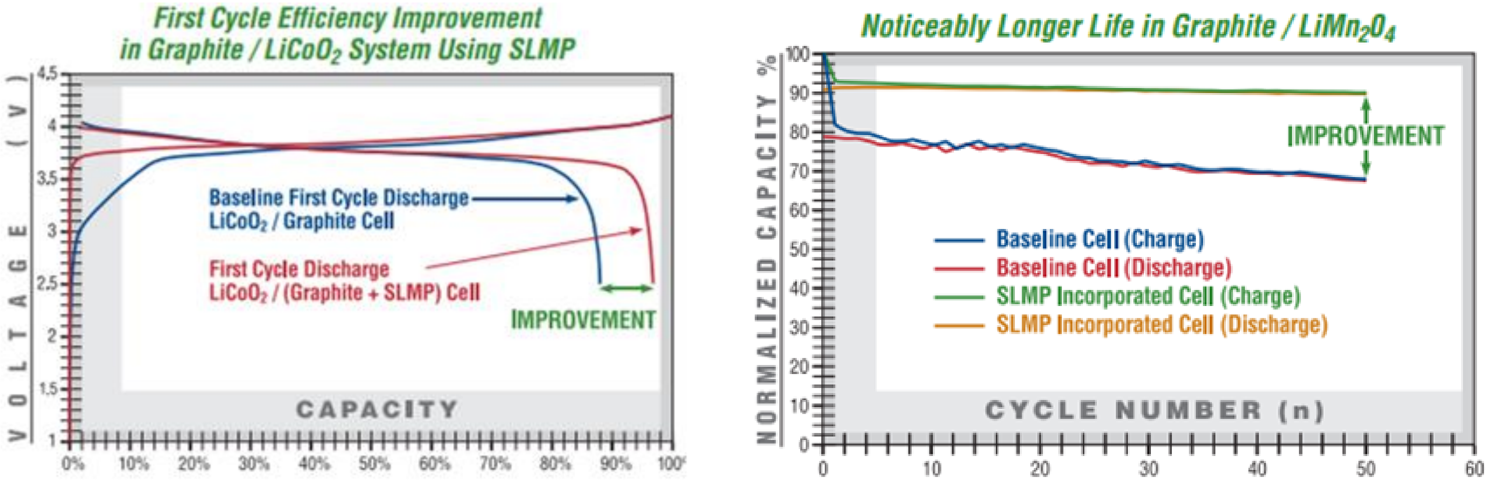


Image 2-3: Diagram of data collected by FMC Lithium proving SLMP advantages.

Marcos Leon

Current Methods

- The only current technology available for coating SLMP is a slurry application developed by FMC Lithium
  - In this method, the SLMP is mixed into a slurry using a volatile solvent.
  - After application of the slurry, the solvent evaporates and leaves a well distributed coat of SLMP.

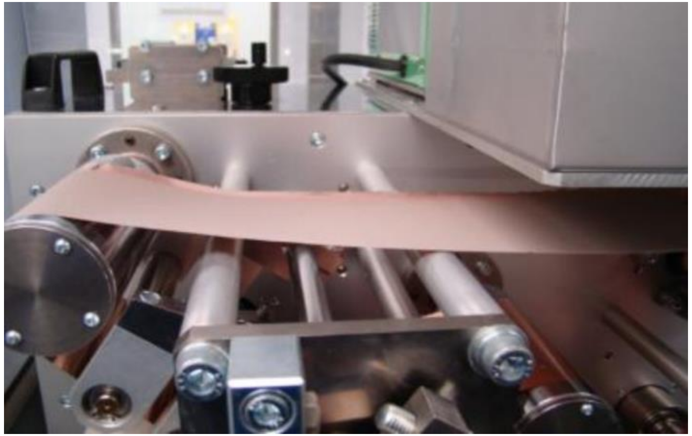


Image 4: Image from Slurry application.

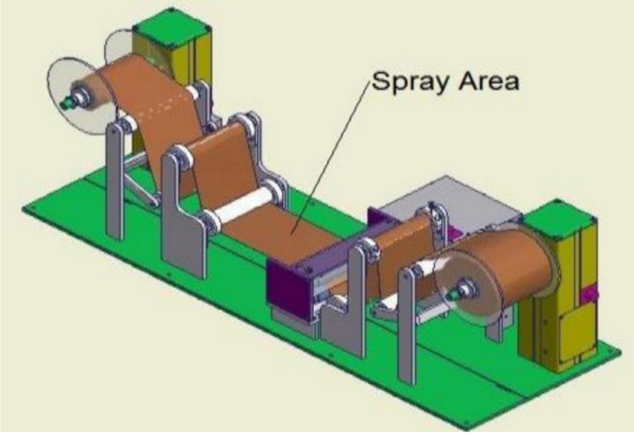


Image 5: Diagram of Slurry Process.

Current Methods

- Tokyo Electron Limited
  - Apparatus for lithium ion capacitor and electrode
  - Pub. No.: US 2014/0178594 A1
- Method: Form a thin lithium film on anode sheet by melting and spraying lithium-containing powder.
  - Using argon gas to melt.

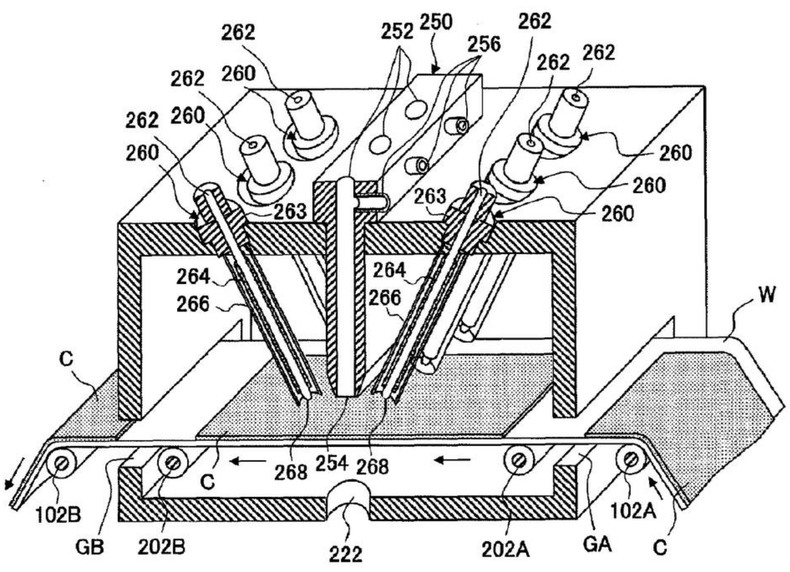


Image 6: Tokyo Electron Limited coating machine

Final Design Chosen

- Dry method design
- Semi-automatic operation
- Adjustable powder flow
- Satisfies safety requirements

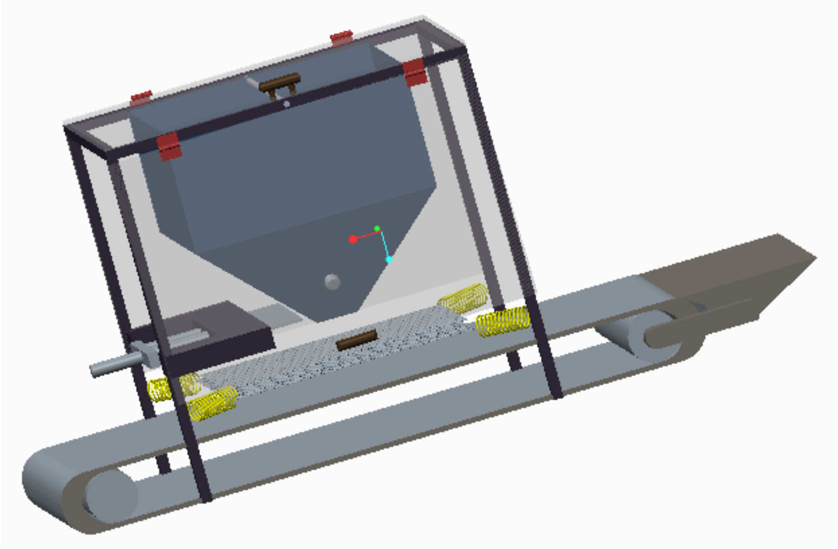


Image 7: View of Final Design

Mechanical Components

Funnel

- Function: To feed SLMP through to meshes
- In-house Construction

Actuators

- Function: To vibrate the funnel which houses the
- Supplier: Precision microdrives
- Selection

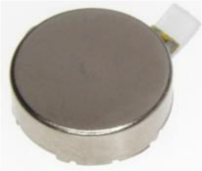


Image 8.Photo of actuator Product number: 310-117

Product Number	Product Name	Quantity	Voltage	Amplitude
310-004	Pico Vibe 10mm vibration motor	1	1.5 V	0.5 G
310-117	Pico Vibe 10mm vibration motor	2	3 V	1.9 G
310-118	Pico Vibe 10mm vibration motor	1	3 V	1.1 G

Mechanical Components

- Conveyor belt
  - Function: To move anode from coating postion into Rolling press
  - In- house Construction
    - Rollers
    - Belt
    - Motors
- Electric Precision 4” width Rolling Press with Dual Micrometer
  - Function: To break and activate the carbonlithate coating on the SLMP coat
  - This rolling press will provide a minimum of 22.24 MPa of pressure
  - Supplied by our sponsor and liaison, Dr.Zheng.
  - Manufactured by MTI Corporation

Image 9: The rolling press. Image take from MTI Corporation.

Mechanical Components

- Meshes
  - Function: Will be used to sieve through SLMP to avoid particle agglomeration and to ensure a constant flow rate of SLMP being dropped onto anode
  - To find an appropriate mesh count the following equation was used:

    PS= particle size

    MC=Mesh count

    tw= thickness of wire

$$PS = \frac{1}{MC} + tw$$

Vannesa Palomo

Mechanical Components

- To calculate open area percentage the following equation was used:

  $$\% \text{ Open Area} = (\text{Opening size} \bullet \text{Mesh Count})^2 \times 100$$

- Mesh selection
- Supplier: Grainger Industrial Supply

Wire mesh	Wire Diameter	Width Opening	% Open Area	Material
150 X 150	0.06604 mm	0.10414 mm	37.90%	304 Stainless Steel
200 X 200	0.05334 mm	0.07366 mm	33.60%	304 Stainless Steel
250 X 250	0.04064 mm	0.06096 mm	36.00%	304 Stainless Steel

Electrical Components

Image 10: Arduino Uno R3
Front View

MCU - Arduino Uno R3 Microcontroller

- This MCU will be the “brains” of the operation by:
  - Controlling the various motors
  - Allows for a on/off switch control the machine
- Technical Specifications
  - Input Voltage: 7-12V
  - Digital I/O Pins: 14
  - PWM Digital I/O Pins: 6
  - Flash Memory: 32 Kb
  - Clock Speed: 16 MHz
  - Capable of being powered by a USB connection from an AC to 12 VDC converter.

Adafruit Motor Shield

- Stackable allowing for 2 additional stepper motors to be controlled
  - 3A peak current capacity

Electrical Components

- (2) 12V Stepper motors for conveyor belt.
- (2) 12V DC motors to allow for variable coating width.
- 16X2 Character Display to communicate with user
- On/Off Switch
- 12 key – Keypad
- A 350W (Corsair RM350) power supply will be needed to supply power.

Image 11: 16X2 Character Display

Components	Nominal Volatage (V)	Average Current	Average Power (W)	Total Power (W)
Arduino Uno R3- MCU	12 V	50 (mA)	0.6	**0.6**
Conveyor Motors (2)	12 V	.35 (A)	4.2	**8.4**
Adjusting Motors (2)	12 V	1.5 (A)	18	**36**
Acuators (4)	2 V	69 (mA)	0.138	**0.552**
Character Display	5 V	15 (mA)	0.075	**0.075**
Keypad	2 V	10 (mA)	0.02	**0.02**
			Total Power	**45.647**

Power Consumption Table

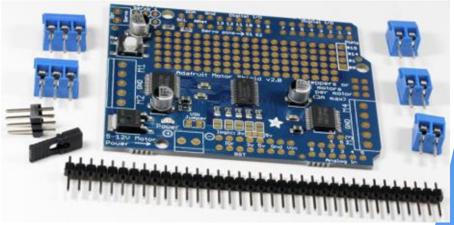
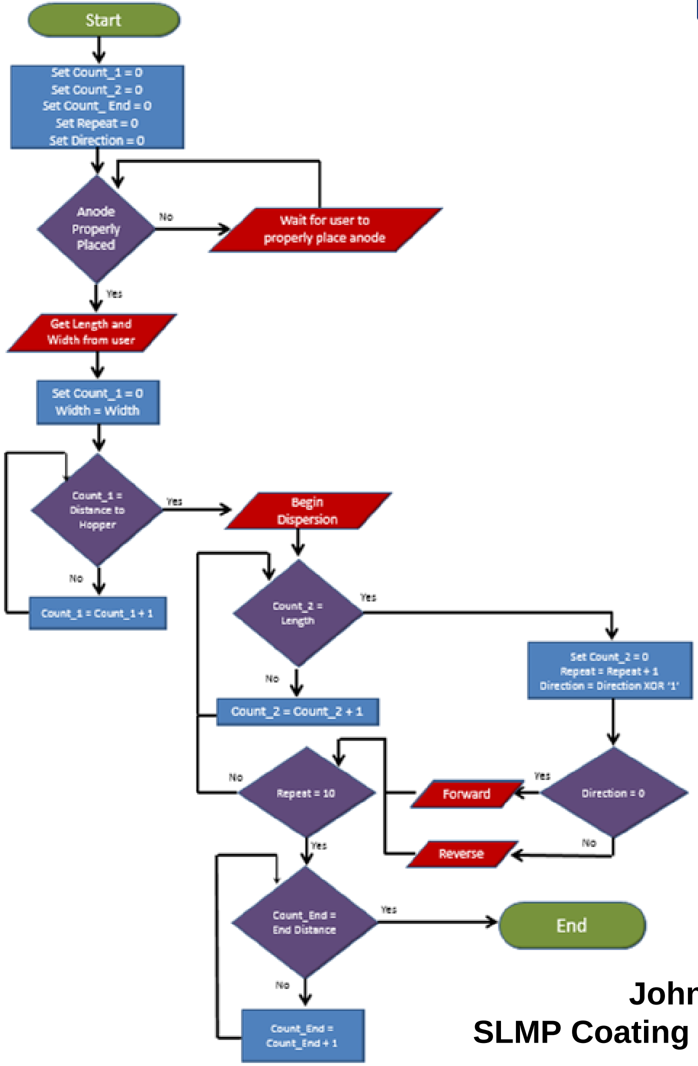


Image 12: Arduino Motor Shield

Programming Flow Chart

- Programming Language:
  - Arduino coding
- Estimated Time for completion of Program
  - Goal : Early-February
- Addition Debugging and modifications that may arise to be completed beginning of March



John Magner
SLMP Coating Machine

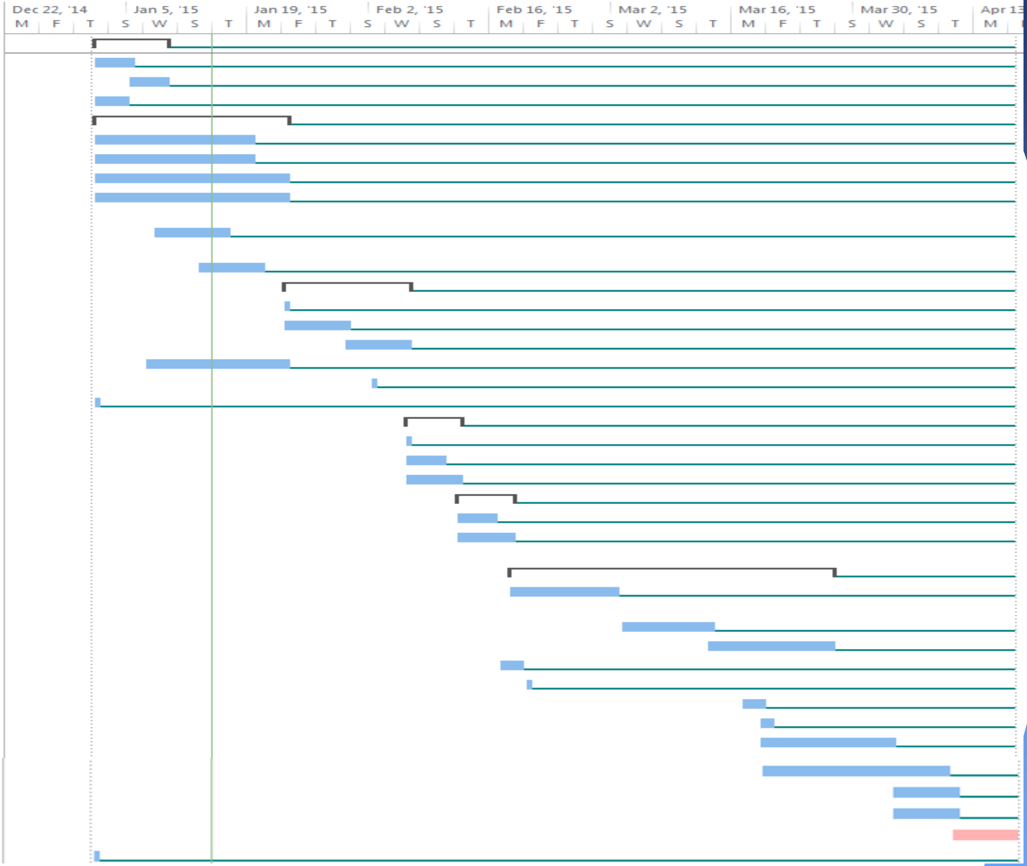
Procurement Process				
Components	**Distributor/ Source of Part**	**Quantity**	**Price**	**Status of Component**
Meshes	Grainger Industrial Supplier	3	$ 65.38	In Transit
Frame	Metal Fabrication and Sales of Tallahassee	1	$ 200.00	Fabrication Phase
Conveyor Belt	In-house Construction	1	$ 175.00	Ordered
Flap	In-house Construction	1	$ 30.00	Ordered
Funnel	In-house Construction	1	$ 200.00	Fabrication Phase
Actuator	Precision Microdrives	4	$ 63.79	In Transit
Plexiglass	Amazon	1	$ 7.99	In Transit
Microprocessor	Arduino	1	$ 29.95	Arrived
Stepper Motor	Sparkfun	2	$ 32.99	In Transit
DC Motor	Sparkfun	2	$ 30.00	Ordered
Character Display	Sparkfun	1	$ 4.99	In Transit
Keypad	Sparkfun	1	$ 8.99	In Transit
On/off switch	Sparkfun	1	$ 1.99	Arrived
Power Supply	Cosair	1	$ 39.99	Ordered
Hinges	Home Depot	2	$ 3.39	Arrived
Motor Shield	Amazon	1	$ 34.95	In Transit
		Total =	$ 929.40	

Budget

- Total alloted Budget
  - $2,000 USD
- Current Funds Spent on Procurement:
  - $ 929.40 USD
- 46.47% of budget has been used

Schedule

Name	Duration	Start	Finish
Continued Design Analysis	**6.5 days?**	**Thu 1/1/15**	**Fri 1/9/15**
Mechanical	2.5 days?	Thu 1/1/15	Mon 1/5/15
Electrical	4.5 days?	Mon 1/5/15	Fri 1/9/15
Material Selection of Components	2.17 days?	Thu 1/1/15	Mon 1/5/15
Procurement	**17 days?**	**Thu 1/1/15**	**Fri 1/23/15**
Place orders on all parts	12.5 days?	Thu 1/1/15	Mon 1/19/15
Purchase of all standard parts	12.5 days?	Thu 1/1/15	Mon 1/19/15
Check of all components ordered	16.5 days?	Thu 1/1/15	Fri 1/23/15
Submit paperwork for reimbursement	17 days?	Thu 1/1/15	Fri 1/23/15
Restated Project Definition and Scope Project Plan	6.5 days?	Thu 1/8/15	Fri 1/16/15
Presentation 1	5.5 days?	Tue 1/13/15	Tue 1/20/15
Construction	**10.5 days?**	**Fri 1/23/15**	**Fri 2/6/15**
Initiation of Construction	1 day?	Fri 1/23/15	Fri 1/23/15
Completion of Mechanism	5.5 days?	Fri 1/23/15	Fri 1/30/15
Mechanism Check	5.5 days?	Fri 1/30/15	Fri 2/6/15
Team evaluation Report 1	12.5 days?	Wed 1/7/15	Fri 1/23/15
Webpage Update	1 day?	Mon 2/2/15	Mon 2/2/15
Testing Phase	1 day?	Thu 1/1/15	Thu 1/1/15
Initiate Testing	**4.5 days?**	**Fri 2/6/15**	**Thu 2/12/15**
Using Alternative mediums	1 day?	Fri 2/6/15	Fri 2/6/15
Analysis of round 1 of testing	2.5 days?	Fri 2/6/15	Tue 2/10/15
Revision mechanism	4.5 days?	Fri 2/6/15	Thu 2/12/15
Testing Round 2	**4.5 days?**	**Thu 2/12/15**	**Wed 2/18/15**
Analysis of round 2	2.5 days?	Thu 2/12/15	Mon 2/16/15
Revisions based on round 2 of testing	4.5 days?	Thu 2/12/15	Wed 2/18/15
Final Stage of testing	**27.5 days?**	**Wed 2/18/15**	**Fri 3/27/15**
final check of system using alternative medium	8.5 days?	Wed 2/18/15	Mon 3/2/15
Test Using SLMP	8.5 days?	Tue 3/3/15	Fri 3/13/15
Complete any revisions required	10.5 days?	Fri 3/13/15	Fri 3/27/15
Midterm Presentation 1	2.5 days?	Tue 2/17/15	Thu 2/19/15
Team Evaluation 2	1 day?	Fri 2/20/15	Fri 2/20/15
Midterm Presentation 2	2.5 days?	Tue 3/17/15	Thu 3/19/15
Team evalution 3	1.5 days?	Thu 3/19/15	Fri 3/20/15
Operational Manual, Design Report for Manufacturing/ Reliability and	11.5 days?	Thu 3/19/15	Fri 4/3/15
Walk through Presentation	15.5 days?	Thu 3/19/15	Thu 4/9/15
Final Report	5.5 days?	Fri 4/3/15	Fri 4/10/15
Final Webpage	5.5 days?	Fri 4/3/15	Fri 4/10/15
Final Presentation	5.5 days?	Fri 4/10/15	Fri 4/17/15
Team Evaluations 4	1 day?	Thu 1/1/15	Thu 1/1/15



Vannesa Palomo
SLMP Coating Machine

Initial testing

- Manual sifting of meshes
- Conduct experiments with different mediums:
    - Sugar
    - Flour
    - Microcarbon beads
- Begin testing with actuators and funnel to determine flow rate and dispersion area

Image 13: Photo of Dr.Zheng's Lab Dry Room

Questions/Comments

- We would like to open the floor to any questions or comments.

References

- FMC Corporation, O. "Introducing Stabilized Lithium Metal Powder." *SLMP — More Energy, More Stability, More Value. Only from FMC Lithium.* (n.d.): n. pag. *Introducing Stabilized Lithium Metal Powder*. FMC Lithium, 2010. Web. 2014.
- Groover, M. (2010). CH 16 Powder Metallurgy. In Fundamentals of modern manufacturing: Materials, processes, and systems (5th ed., p. 1024). Upper Saddle River, N.J.: Prentice Hall.
- Zheng, J.P. "Nano-structured Materials for Energy Storage and Conversion." *Anode Electrode*. N.p., n.d. Web. 2014.