

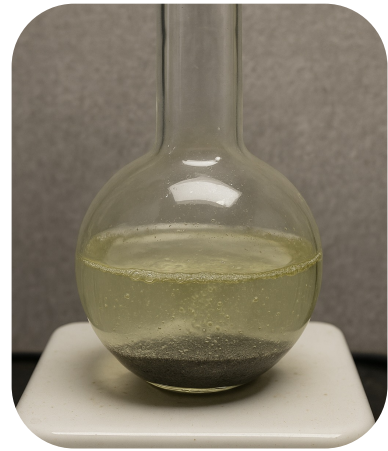


Anorthite



**Can we close the loop between
resource extraction and
manufacturing 239,000 miles
away?**

Demonstration of the critical steps for **Aluminum** production



Regolith
Simulant

Chemistry

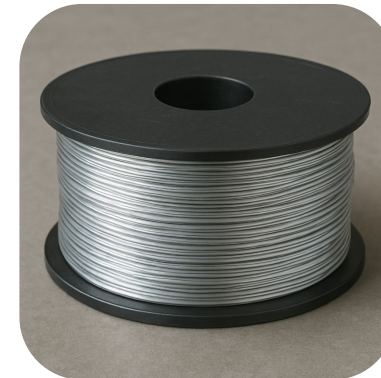


Alumina Al_2O_3



Metallic
Aluminum

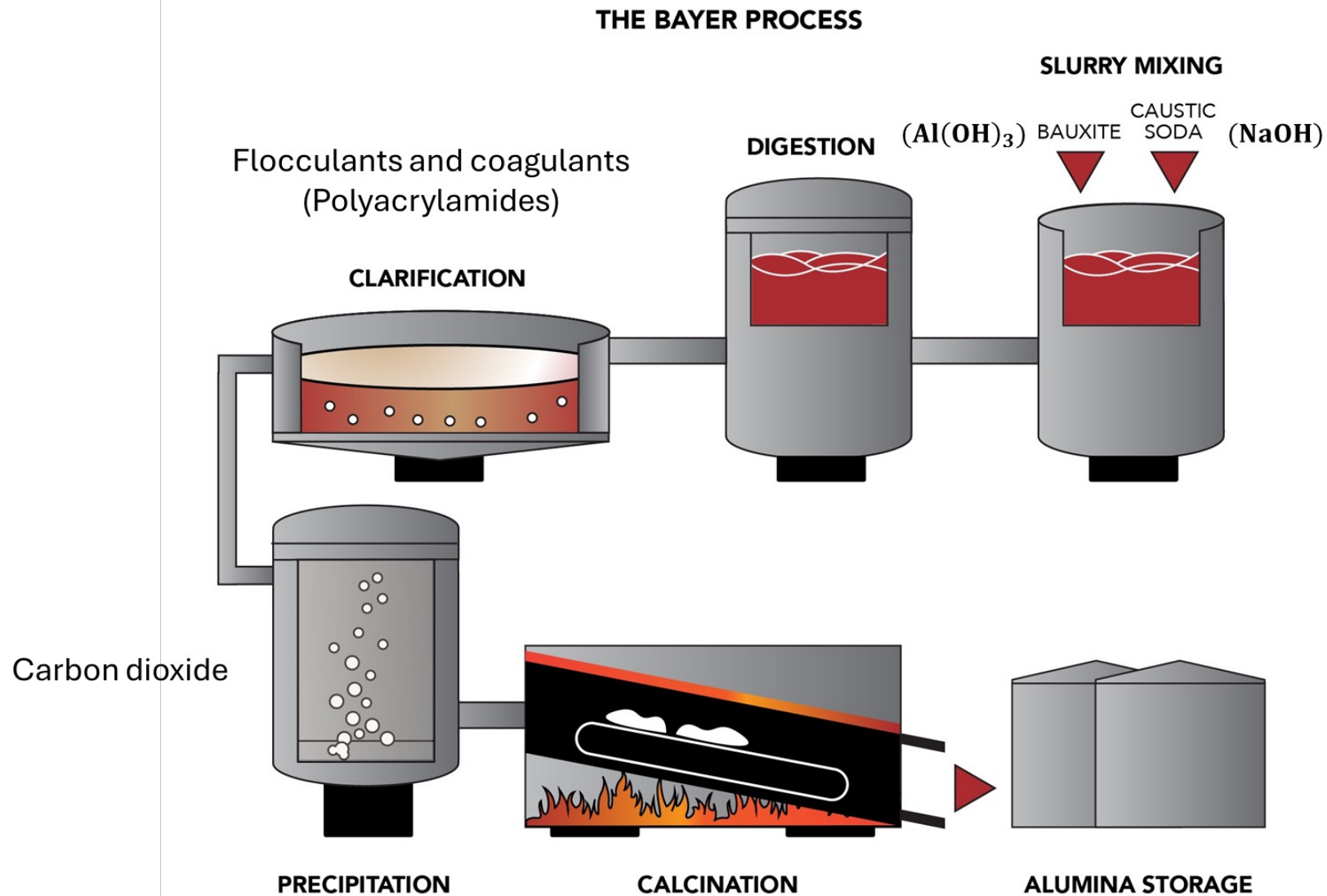
Manufacturing



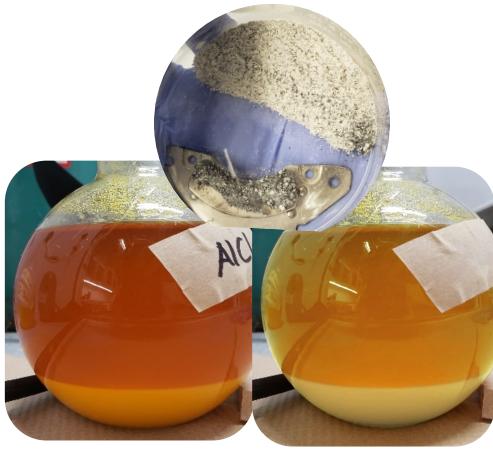
1. Preprocessing



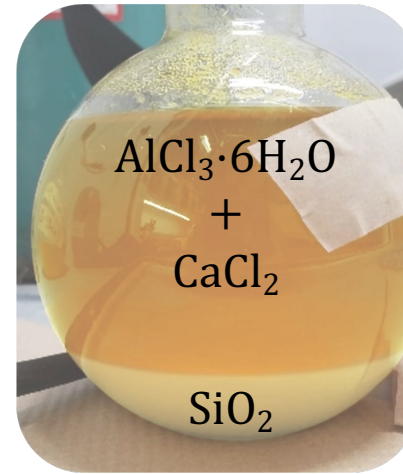
Alumina (Al_2O_3) extraction on Earth



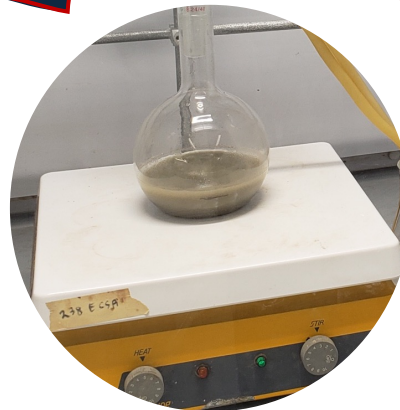
From a lunar regolith simulant to **alumina** (Al_2O_3)



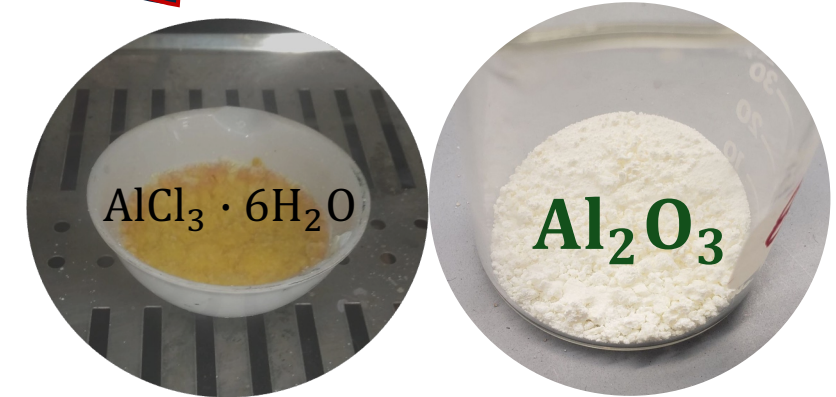
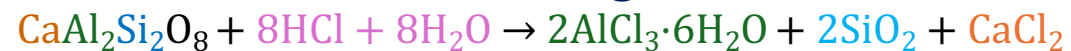
Beneficiation



Separation



Leaching



Calcination

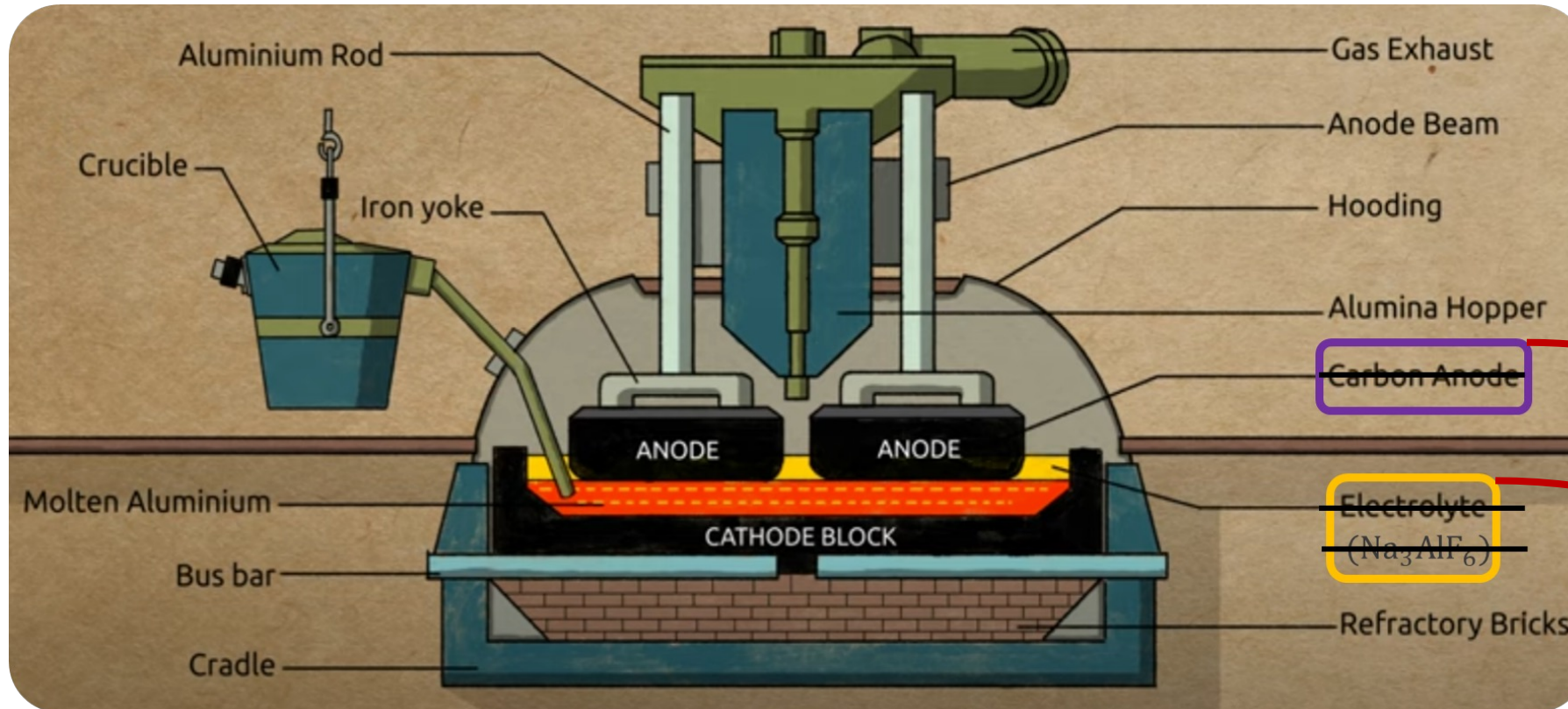


HCl + H₂O

2. Electrochemical reduction



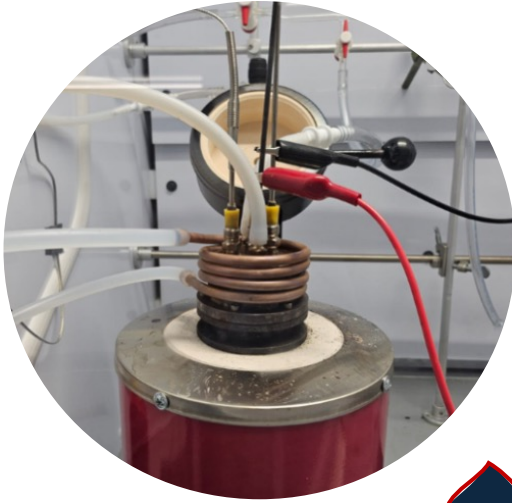
Aluminum extraction Earth vs. Moon



**Inert Electrode
(i. e. Sn Doped)**

CaCl_2

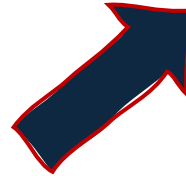
Production of metallic **aluminum** (Al)



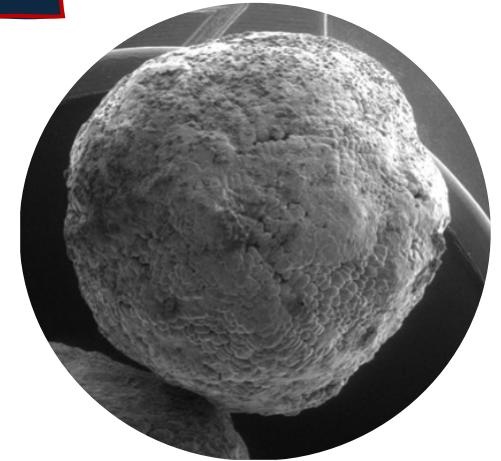
**Building an
electrochemical
reactor**



**First Promising
Results**



**Successful Al
Production**



Analysis

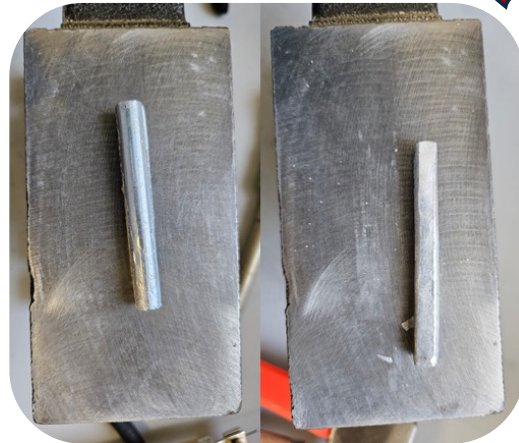
3. Wire Fabrication



Production of aluminum **wire**



Casting



Forging

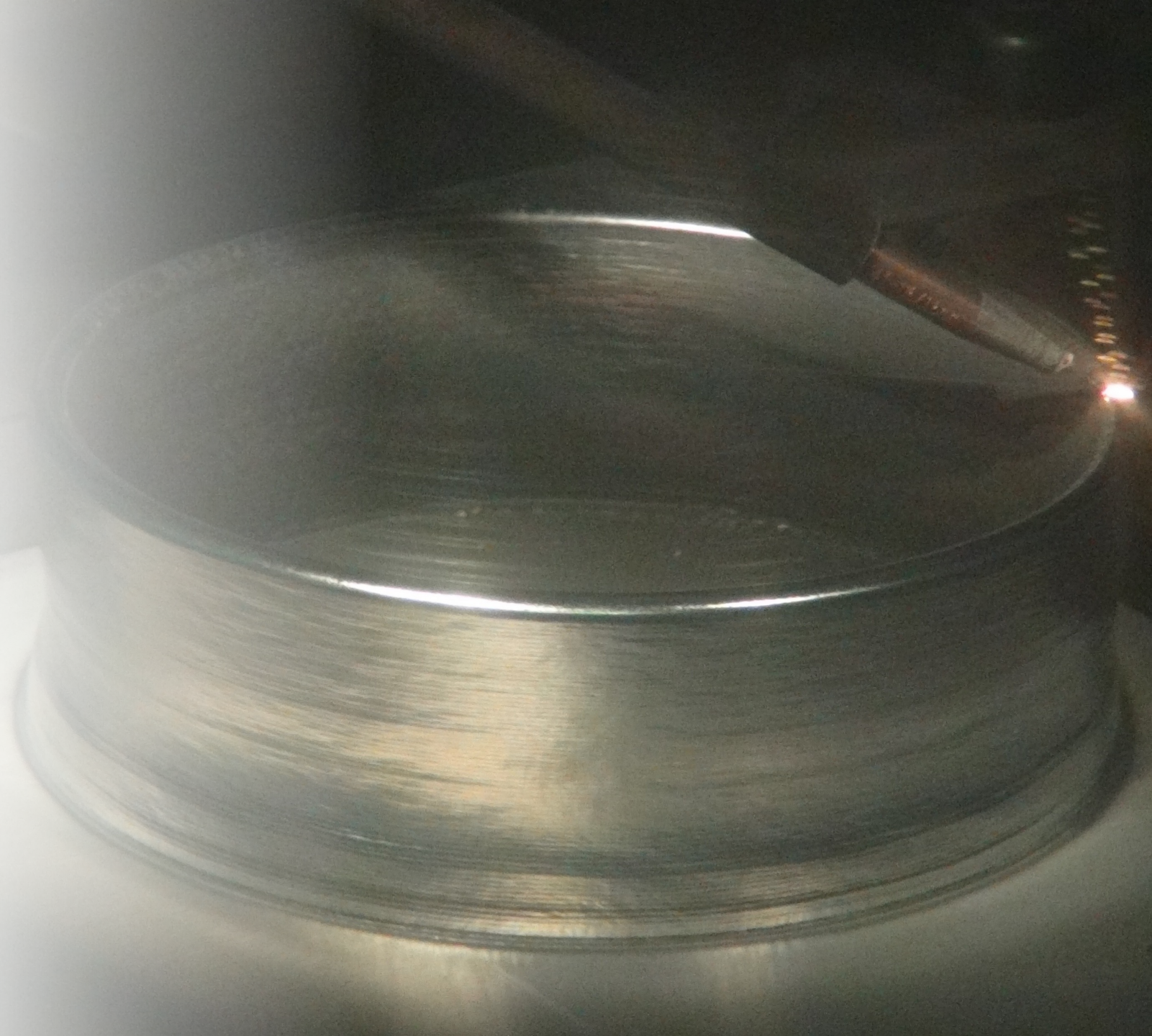


Rolling

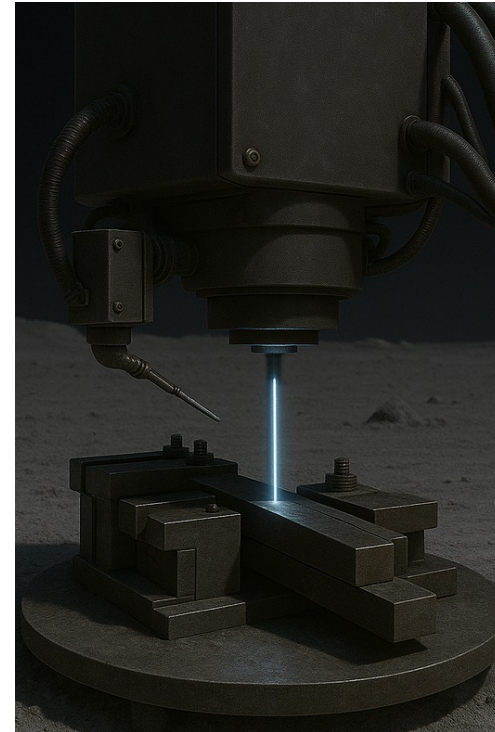
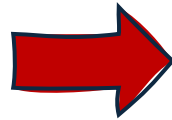
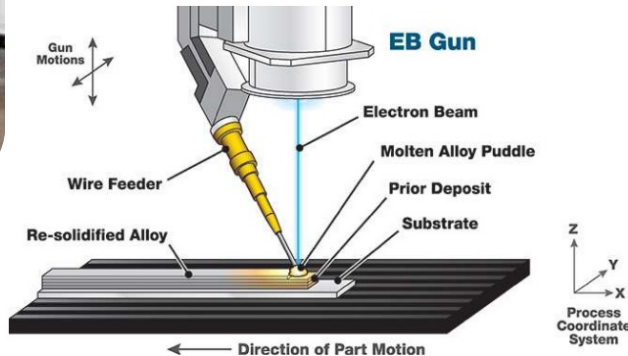
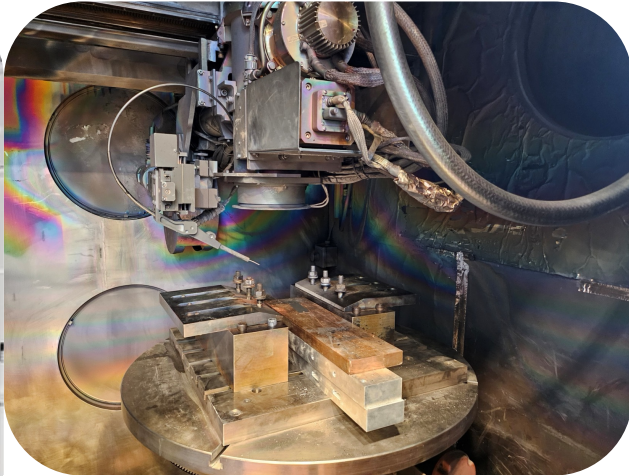


Drawing

4. Al Electron Beam Additive Manufacturing

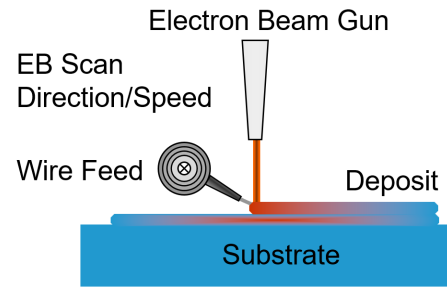


Electron beam additive manufacturing



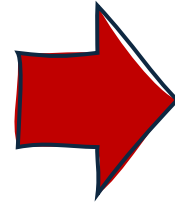
- Natural vacuum on the Moon
- On Earth, much of the EBAM infrastructure is devoted to maintaining the vacuum
- Better energy efficiency per finished part
- Saves material and post-processing energy
- High deposition rates

Testing Process Parameters



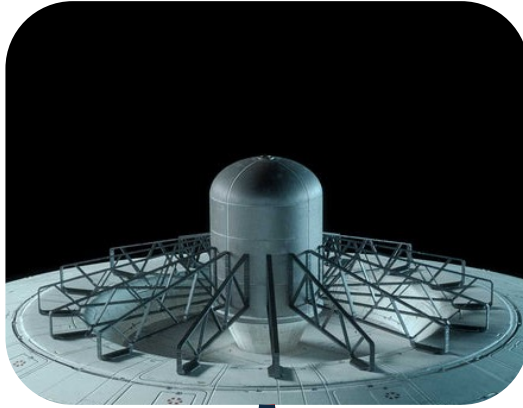
Standardization of Process Parameters

- ✓ Voltage
- ✓ Current
- ✓ Beam diameter
- ✓ Scan speed
- ✓ Wire feed rate





Printing Demonstrators



**Over accumulation on
the top**



**Material sinking at the
center**



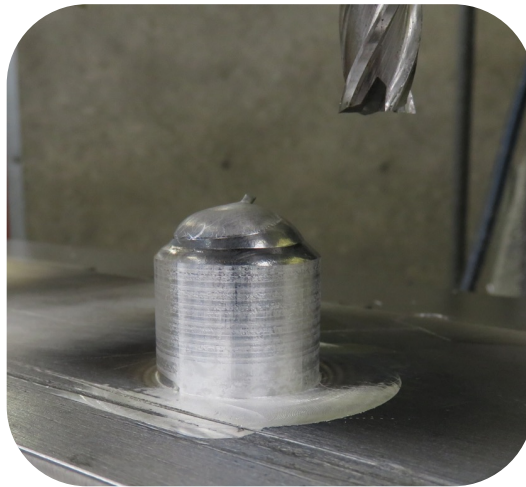
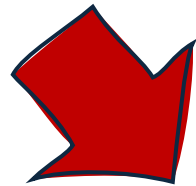
Successful deposition



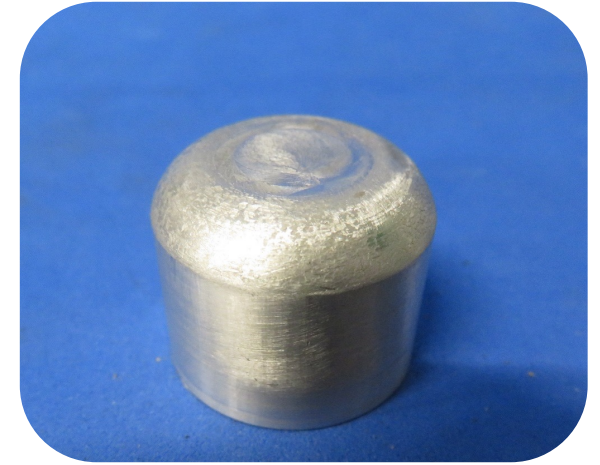
Machining



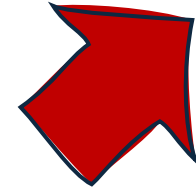
**EBAM material
deposited on the build
plate**



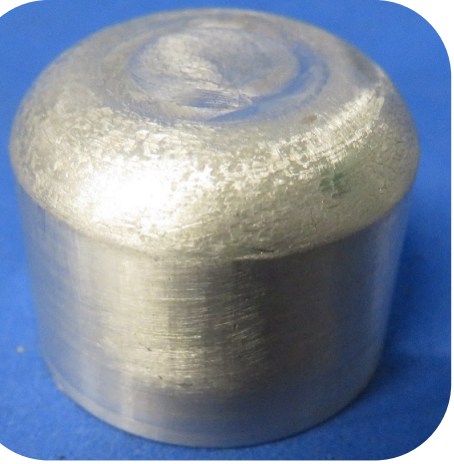
**EBAM part during
machining**



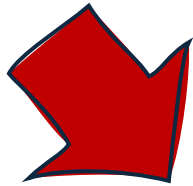
**EBAM part removed
from build plate with
improved surface
finish.**



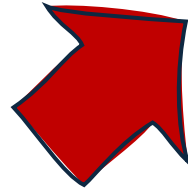
Electron beam welding



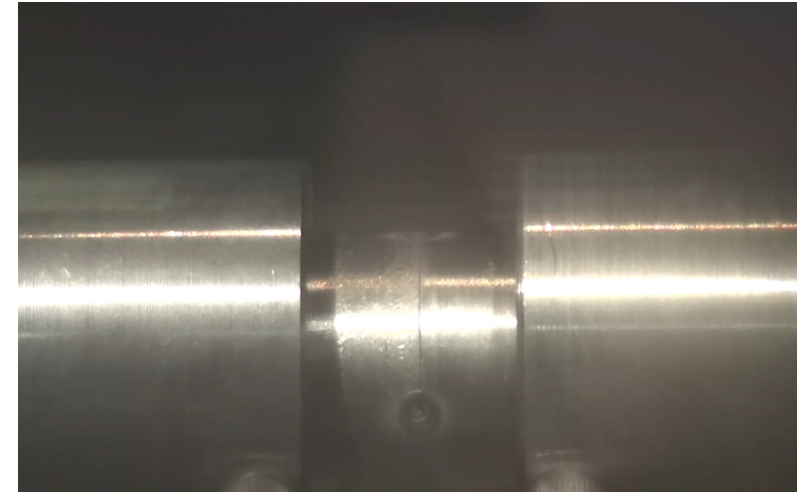
**Single EBAM
machined part**



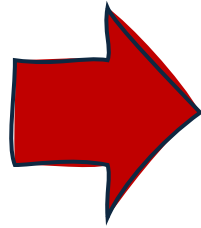
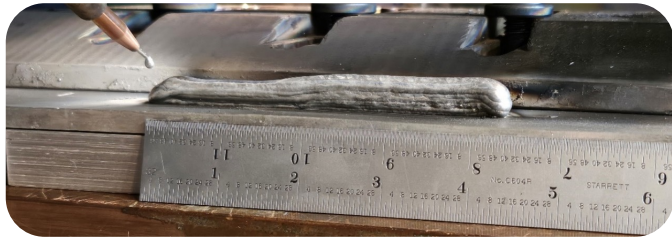
**Pre-weld assembly
of two EBAM parts**



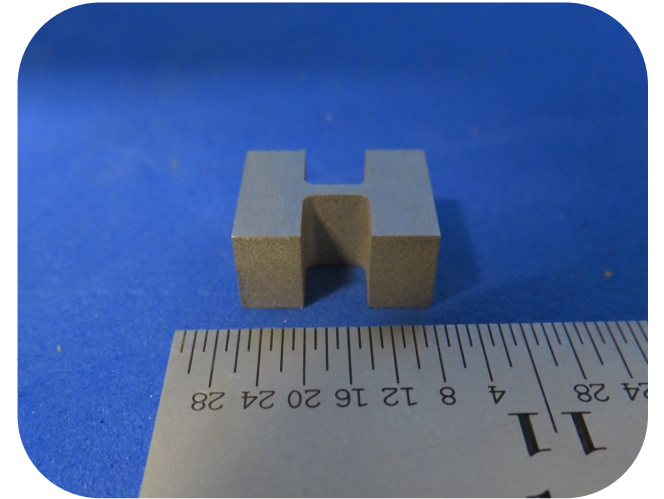
**Finished
demonstrator
fabricated by EB
welding**



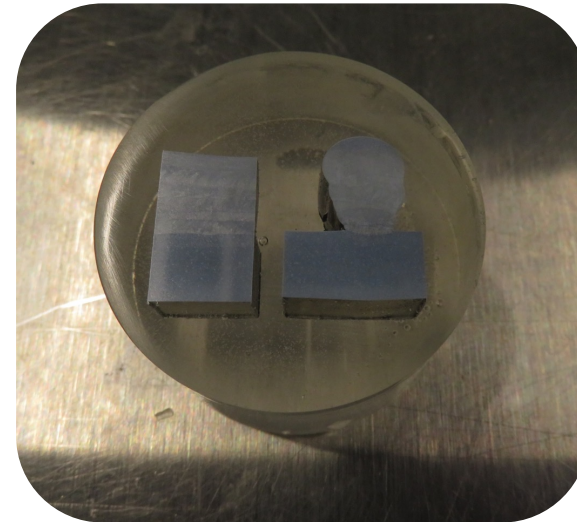
Analysis of deposited aluminum



Microstructure



Tensile Testing



Hardness



Alex Ellery



Kate Marczenko



Bertrand Thibodeau



Xavier Walls



Priti Wanjara



Sheida Sarafan



Javad Gholipour

Thank you!

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University



Canada
NRC-CMRC