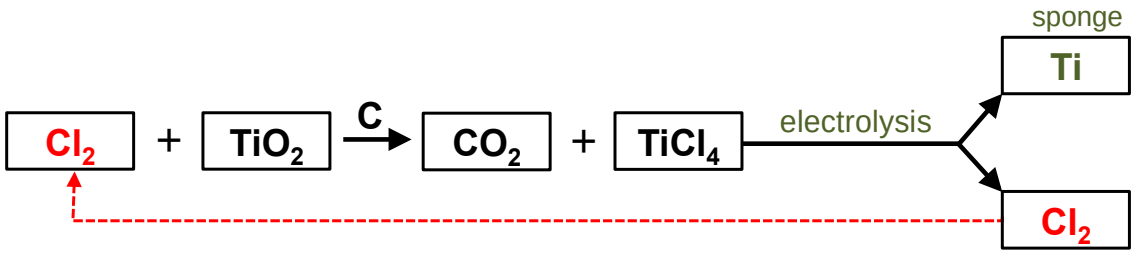
Titanium Electrowinning Process

Case Western Reserve University (PI: Rohan Akolkar)

August 24 – 25, 2016
Detroit, MI

METALS Annual Meeting

Proposed Electrowinning Process



Outline

- Team Intro
- Technical Concept
- Technical Progress to date
- TEA Highlights
- Future Goals
- Q&A

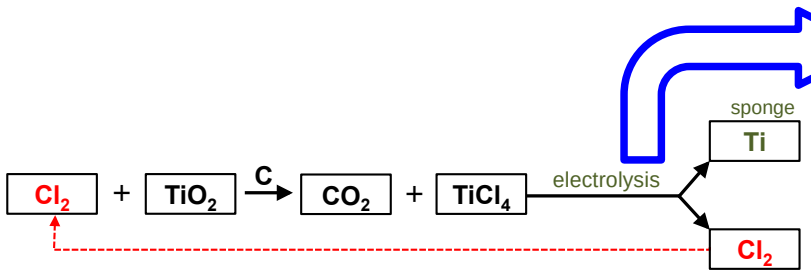
Case Western Reserve University

- Case Western Reserve University Team Members:

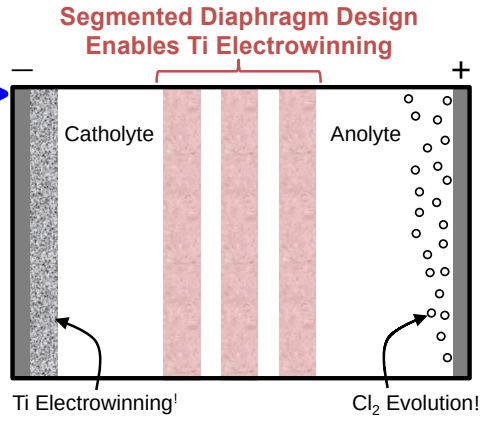
  PI: Rohan Akolkar
  Personnel: Dai Shen, Stephen Banik, Mirko Antloga, Craig Virnelson, Uziel Landau, Mark DeGuire, David Zeng

- Goals of the ARPA-E METALS Project:
  - To develop a novel electrowinning process for low-cost extraction of titanium metal from ore, and
  - Demonstrate stable, energy-efficient extraction of high-purity Ti powder

Proposed Electrowinning Process

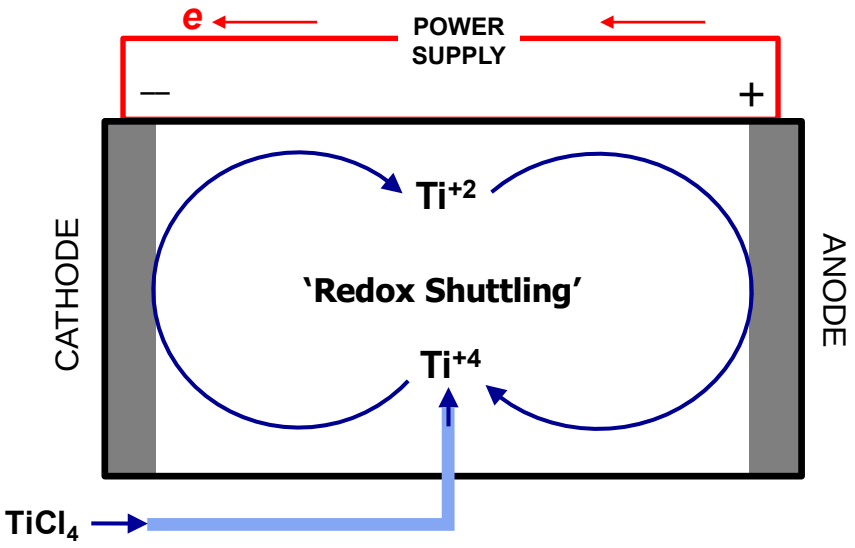


Proposed Electrowinning Cell Design



Technical Concept

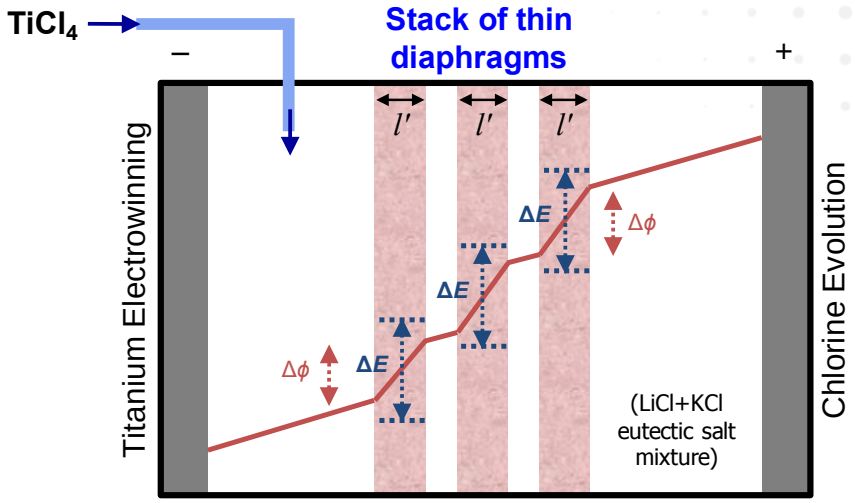
PROBLEM STATEMENT



Problem with diaphragm-less cell:
Redox shuttling of titanium ions causes low current efficiency

PROPOSED SOLUTION

Use a stack of thin diaphragms



Design Rule: $\Delta\phi = il'/\kappa < \Delta E$

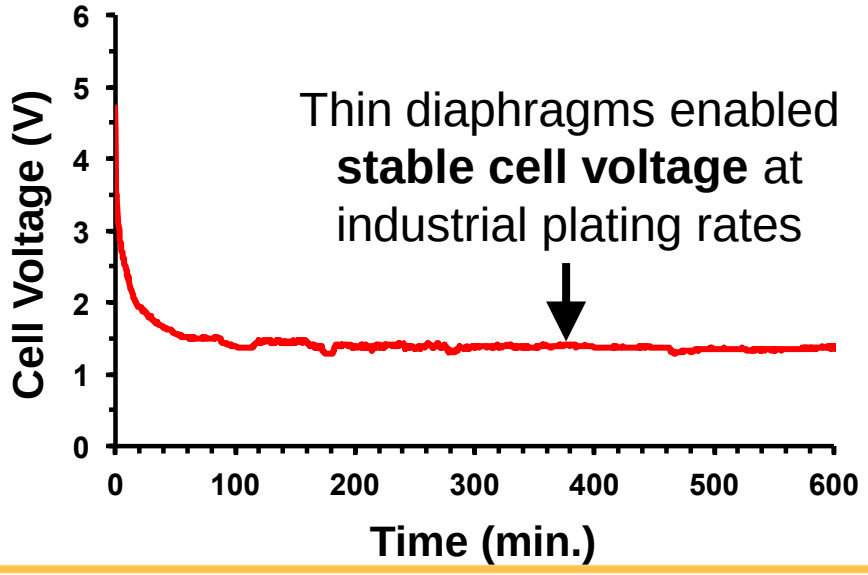
Ensures diaphragm & cell stability

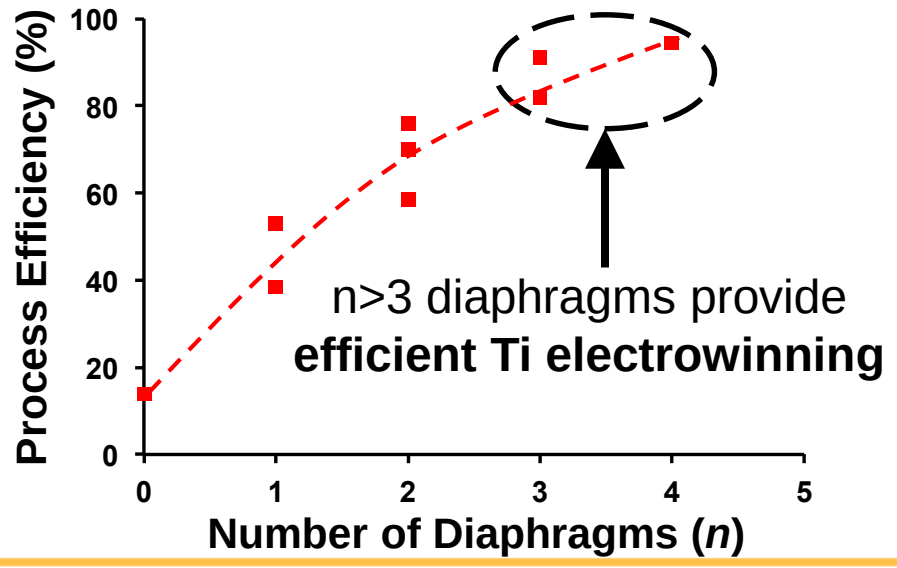
Increases electrowinning efficiency

Technical Progress (Phase-I)

Molten-salt electrowinning reactor was constructed and operated

Ti sponge was deposited, isolated and then characterized



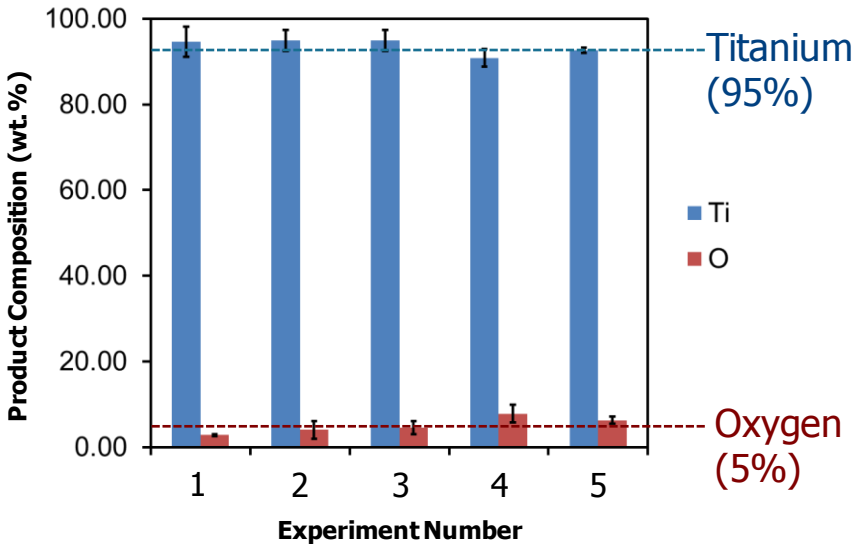


Technical Progress (Phase-II)

Molten-salt electrowinning reactor was relocated inside a glove-box for controlled environment studies

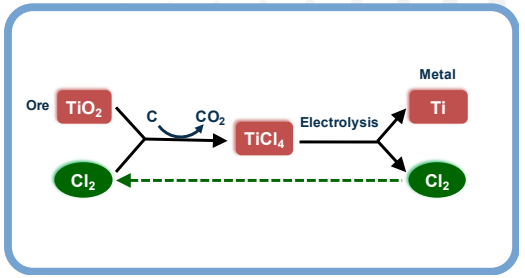
~100 mg Ti deposits were collected and analyzed for purity using EDS

EDS analysis shows up to 5 wt.% oxygen contamination in the electrowon Ti deposits



CHANGING WHAT'S POSSIBLE

TEA Highlights

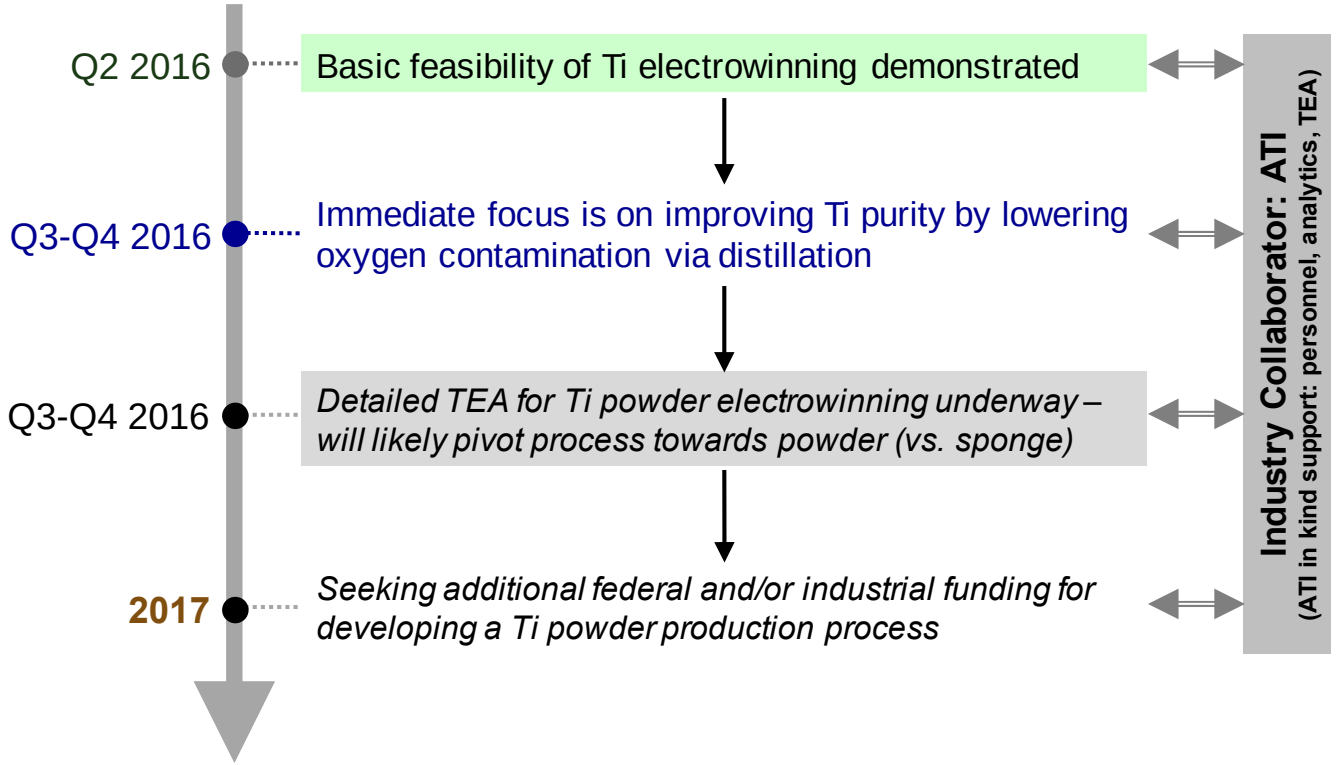


Metric	ARPA-E METALS GOALS	Proposed Technology (Ti Electrowinning)
Cost of Ti Sponge	< $4 / kg	**$4-5 / kg**
Energy Consumption	< 35 kWhr / kg	**25-30 kWhr / kg**
CO_2 emissions	< 11 kg-CO_2 / kg	**12-15 kg-CO_2 / kg**

- Cost reduction primarily driven by energy-efficiency and process simplicity (elimination of the sacrificial Mg recycling as needed in conventional Kroll process)

Future Goals

- Purity improvements:
  - Currently, oxygen contamination of Ti product is a technology risk. To address this risk, we are designing an efficient vacuum distillation unit to purify the Ti product with the goal of achieving >99% purity.



QUESTIONS?