# Resin Wafer-Electrodeionization for Flue Gas Carbon Dioxide Capture

DOE Program Announcement Number: DE-FOA-0000065

ARPA-E Award: DE-AR0000024

Argonne NATIONAL LABORATORY

NALCO Essential Expertise for Water, Energy and Air

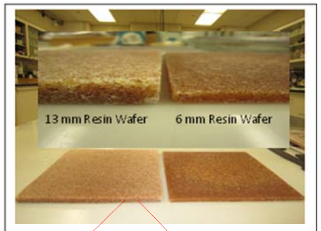
## Project Goals

- Develop Resin Wafer- Electrodeionization technology for $CO_2$ capture
- Target 90% $CO_2$ capture and release with 90% purity at COE target of less than 50%

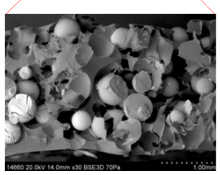
## Strategy

- Simultaneous $CO_2$ absorption & release
- Employ electrochemical pH control
- Decrease parasitic energy load

## Resin Wafer

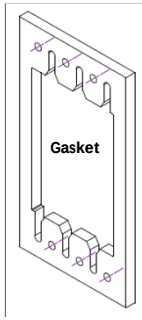



- Thickness: 6 and 13 mm in 11"x11"
- Porosity: 30% to 40%
- Ionic conductivity: 1.5 to 4.0 mS/cm
- Resin type: gel cationic and anionic
- Particle sizes: 50 µm to 400 µm

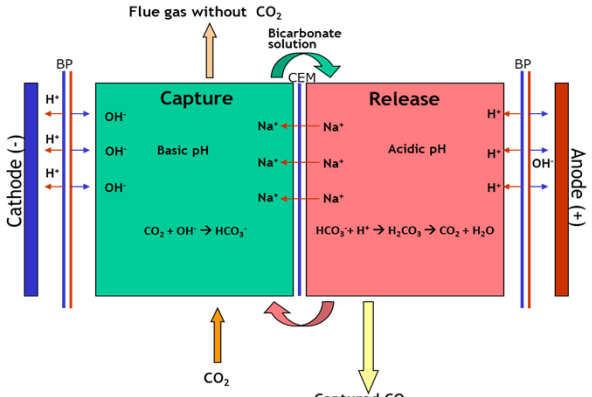


Scanning electron microscope image

Resin wafer held within a gasket



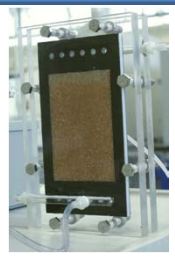

## Single Cell EDI




- Electrochemical pH control
  - Capture Cell – basic pH
  - Release Cell – acid pH
- Water splitting at bipolar membranes
  - Source of $OH^-$ for capture cells and $H^+$ for release cells
  - In-situ ion exchange regeneration
- Cationic-selective membranes
  - Na+ ions migrate into capture cells after $CO_2$ release

## Flow Through Cell

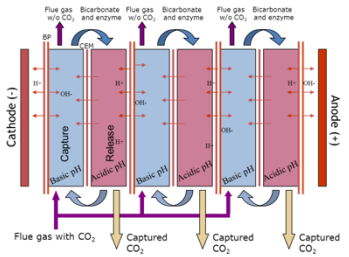
Gas and liquid flowing in a partial resin wafer held within a gasket

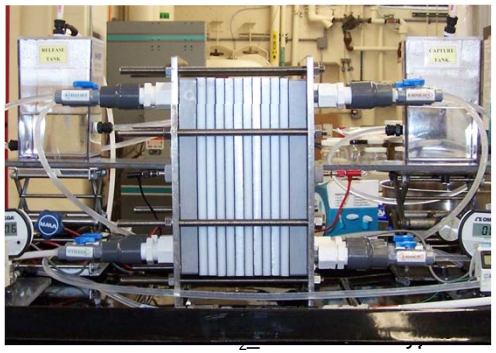


Gas and liquid flowing in a resin wafer held within a gasket

## $CO_2$_RW-EDI

Plate-and-frame module with alternating cationic-selective and bipolar ion exchange membranes between resin wafers



## Gas Analyzers

# Resin Wafer-Electrodeionization for Flue Gas Carbon Dioxide Capture

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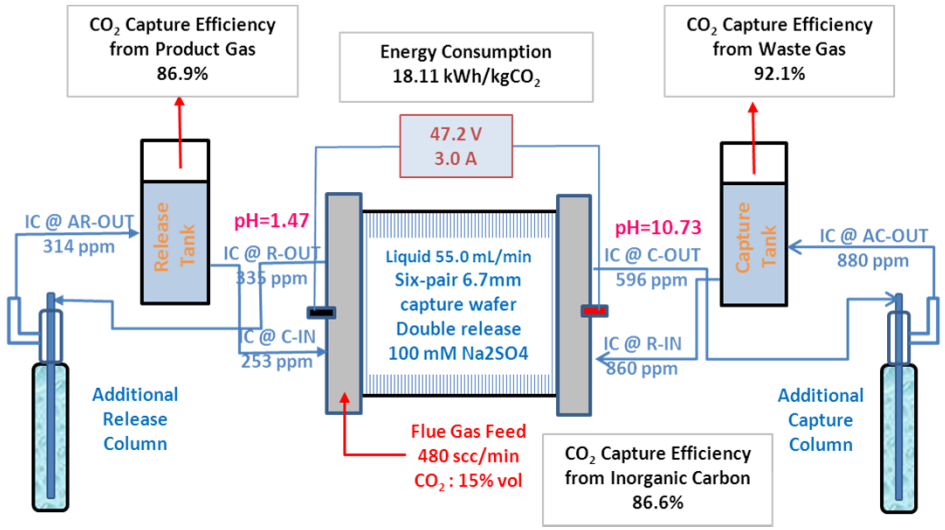
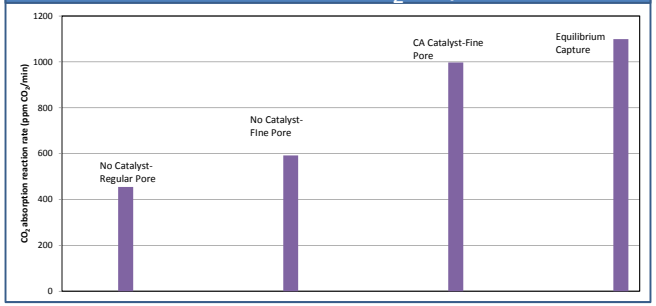
## $CO_2$ Mass Balance: Inorganic Catalyst




## Effect of Pore Size on $CO_2$ Capture Rates




## Conclusion

- The process achieved 90% $CO_2$ capture at 90% purity and exceeded the energy consumption target.

## Summary of Improvements

| System | G/L Ratio | Gas Flow Rate scc/min | % Capture | Electrical Power KWh/Kg $CO_2$ |
|---|---|---|---|---|
| **Baseline Wafers** | **3** | **240** | **53** | **57** |
| **Enzyme Immobilized Wafers** | **5** | **300** | **58** | **16** |
| **Inorganic Catalyst** | **3** | **240** | **81** | **32** |
| **Inorganic Catalyst + Absorption Column** | **5** | **480** | **94** | **20** |
| **Inorganic Catalyst + Absorption Column + Better Gas Distribution** | **15** | **1000** | **46** | **9** |
| **Inorganic catalyst + Absorption Column + Release Column+ Better Gas distribution** | **9** | **480** | **92** | **18** |

## Acknowledgements


**Project Team**

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