CENTER FOR RESOURCE RECOVERY AND RECYCLING (CR³)

An NSF Industry/University Cooperative Research Center
Outline

- The Need for CR³
- Center Mission
- CR³ Team
- Center Research
- Members, Benefits, and ROI
- Join CR³
Metal Production Trends

G. Mudd, 2009, Sustainability of Mining
Trends in Ore Grade

G. Mudd, 2009, Sustainability of Mining

Center for Resource Recovery and Recycling
2010 Recycling Rates in the U.S.

- Auto Batteries: 96.2%
- Newspapers/Mechanical Papers: 71.6%
- Steel Cans: 67.0%
- Yard Trimmings: 57.5%
- Aluminum & Soda Cans: 49.6%
- Tires: 35.5%
- Glass Containers: 33.4%
- HDPE Natural (White Translucent) Bottles: 27.5%
- PET Bottles & Jars: 21.0%

Credit: EPA
Industry Challenges

- Sustainable development most pressing issue of the 21st century; driven by population growth,
- Scarcity of feed stock materials and increasing cost of material resources,
- Increasing amounts of waste from industrial processes as well as end-of-life products,
- Need for solutions for resource recovery, reuse, and recycling of critical materials
- Need for energetically favorable, environmentally compatible and economically viable industrial processes.
The Need for CR³

- Materials are not renewable. Technologies need to be developed for cost-effective recycling and recovery of resources,
- Design of components with end of life recovery/recycling needed to improve recovery/recycling rates,
- Both technological issues as well as policy issues need to be addressed for holistic sustainable solutions,
- Materials resource recovery and recycling is a critical need for sustainable development in the 21st Century,
- Academia-Industry-Government need to work together to tackle these critical issues. CR³ is the first center of its kind established to address these needs.
Center Mission

To be the global *industry-university collaborative* dedicated to the sustainable stewardship of the Earth's resources by *serving as a knowledge base, and developing technologies that can be applied* from initial product design, through manufacture, to end-of-life disposal yielding resource efficiency and including energy savings and improved profitability for the good of all.
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Academic Partners

Worcester Polytechnic Institute (WPI)  Colorado School of Mines  KU Leuven

Center for Resource Recovery and Recycling
CR³ Team

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Center for Resource Recovery and Recycling
Expertise

WPI
- Metal Processing - Sortation and Recycling Technologies
- Electrochemistry – Li Ion Batteries
- Magnets; Rare Earth Metals; post consumer waste

Colorado School of Mines
- Kroll Institute for Extractive Metallurgy (Pyrometallurgy-Hydrometallurgy- Electrometallurgy)
- Mineral Processing
- Rare Earth Metals

KU Leuven
- Materials characterization
- High temperature Metallurgy
- Rare Earth Metals

Center for Resource Recovery and Recycling
Outline

- The Need for CR$^3$
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Center Research

- Research projects are member-driven and each research project has a focus group made up of members who provide an industrial perspective,
- Members submit and vote on proposed projects twice per year ensuring that there are projects in queue when projects come to an end,
- 8-10 projects being sponsored every year,
- The goal of CR$^3$ is to have every member working on a project that is of interest to them,
- Members have the option of sponsoring proprietary projects,
- CR$^3$ does large-scale projects which are funded by the federal government and/or foundations. These projects keep members informed about leading edge technologies.
<table>
<thead>
<tr>
<th>Metal</th>
<th>Iron &amp; Steel</th>
<th>Pb, Zn, Cu, Ni, Co</th>
<th>Al, Li, Mg, Ti</th>
<th>Rare Earth</th>
<th>Ga, In, Te</th>
<th>Refractory Metals</th>
<th>General</th>
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<td>Project Area ↓</td>
<td>Production Process Waste</td>
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**CR³ RESEARCH PORTFOLIO METHODOLOGY**
Completed Research Projects

- Beneficiation of Flat Panel Functional Coatings
- Conditioning of Machined Chips
- Development of Aluminum-Dross Based Materials for Engineering Application
- Physical and Chemical Beneficiation for Recycling of Photovoltaic Materials
- Recycling of Bag-House Dust from Foundry Sand
- Recovery of Rare Earth Metals from Phosphor Dust
Current Research Projects

- Development of a Novel Recycling Process for Li-Ion Batteries
- Dezincing of Galvanized Steel
- Fundamental Study of Lithium Ion Battery Recovery
- Magnet Separation Technologies for Recycling
- Metal Recovery via Automated Sortation
- Molten Metal Compositional Sensing to Enhance Scrap Recycling
- Resource Recovery and Recycling from Shredder Residue in North America
- Rare-Earth Recovery from Magnets, Catalysts, and other Secondary Resources
- Recovery of Rare Earth Metals from Phosphor Dust
- Recovery of Value-Added Products from Red Mud and Foundry Bag House Dust
- Recovery of Zinc and Iron from EAF Dusts
- Synthesis of Inorganic Polymers from Metallurgical Residues
## Research Portfolio

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Case Study: Recycling Green Sand Foundry Baghouse Dust

Opportunity:
- Sand casting is the least expensive of all casting processes for producing metal parts. However, foundry waste from sand casting is estimated at 10 to 15 tons/yr … all of which goes into landfills.

Research Goals:
- Develop an efficient process to liberate reusable products from green sand foundry dust,
- Reduce the costs of buying binders (glue-like materials added to a sand mold to bond sand particles together),
- Improve disposal of remaining materials.

Results You Can Use:
- Created a hydrocyclone process that eliminates the harsh chemicals associated with the recovery of clay and sea coal,
- Improved disposal methods of non-reusable waste, as well as recycling binders,
- Expected to reclaim as much as one million tons (approximately 80 percent) of clay and sea coal that might otherwise go into landfills.
Case Study: Rare Earth Recovery from Phosphor Dust

Opportunity:
- Global demand for rare earths metals is critical for high tech products and manufacturing processes. It is essential that we stop importing them and instead recycle them from secondary sources, like phosphor dust from spent fluorescent lamps.

Research Goals:
- Develop an efficient, economical and industrially feasible flow sheet to recover mixed rare earth oxides from phosphor in spent lamps,
- Provide technology to recycle high value rare earths and reclaim tons of phosphor dust so they don’t go into landfills.

Results You Can Use:
- Reduced dependence on China’s exports, which accounts for 95 percent of global rare earth supply,
- Stabilized effects on price, supply and quality of rare earth oxides,
- Breaching the technology gap for recycling other rare earth-based materials.
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CR³ Members

ALCOA

GTP

Constellium

ERCo

MACHIELS

HARSCO

INDIUM CORPORATION

HYDRO

H.C. Starck

INFINIUM

Surface Combustion

Metallo

Persimmon Technologies

Veolia Environmental Services

Victaulic

WIT Corporation
Member Benefits

- Center members can have the consortia to directly support their research needs with full control of the research through focus group meetings,
- For every two members in the consortium, CR$^3$ is able to conduct one research project providing significantly higher leverage of their research dollars,
- CR$^3$ provides royalty free IP rights to pre-competitive research,
- CR$^3$ conducts two meetings per year to review results and allows the industry members to guide the research direction,
- CR$^3$ provides access to faculty and students and the universities involved; as well as industrial internship opportunities,
- CR$^3$ provides the opportunity for industry members to interact and build relationships to solve common technical problems.
Member ROI

- $\text{CR}^3$ provides the knowledge base for innovative solutions to targeted waste recovery and recycling problems,
- $\text{CR}^3$ assists in commercialization of technical solutions and enhances the competitiveness of our industrial members,
- $\text{CR}^3$ develops talent who can directly assist the industry in technology implementation,
- $\text{CR}^3$ assists in developing low-cost research projects that are relevant for the industrial members,
- Membership fees are leveraged 2.5x to support research portfolio as indirect costs are subsidized.
Join CR³

Membership Information

- $33,000 per year with a signed Membership Agreement,
- Dues are pro-rated for members who join mid-year,
- Contact Carol Garofoli for a complete membership packet at (508) 831-5592 or garofoli@wpi.edu

Visit our website at: