



# CENTER FOR RESOURCE RECOVERY AND RECYCLING

<http://wpi.edu/+CR3>

**An NSF Industry/University Cooperative Research Center**



# University Partners

**CR<sup>3</sup>** Center for Resource  
Recovery and Recycling



**WPI**

**Worcester Polytechnic Institute**



**MINES**

**Colorado School of Mines**

**KU LEUVEN**

**KU Leuven**



東京大学  
THE UNIVERSITY OF TOKYO

**University of Tokyo**

# ***Our Team***

**CR<sup>3</sup>** Center for Resource  
Recovery and Recycling



**Brajendra Mishra**



**Diran Apelian**



**Corby G. Anderson**



**Bart Blanpain**



**Toyohisa Fujita**

# ***Mission***

**CR<sup>3</sup>** Center for Resource  
Recovery and Recycling

- **The Center for Resource Recovery and Recycling (CR<sup>3</sup>) is committed to being the premier cooperative research center focused on sustainable stewardship of the earth's resources.**
- **Our focus is on helping industry address a pivotal societal need – the need to create a sustainable future. At CR<sup>3</sup> you will advance technologies that recover, recycle and reuse materials throughout the manufacturing process. These advancements will help your business reduce energy costs and increase profitability, while protecting our natural resources.**

# ***Our Members***

- **The Aluminum Association**
- **Aurubis**
- **General Motors**
- **Global Mineral Recovery**
- **Gopher Resource**
- **Hydro Aluminium Rolled Products**
- **Indium**
- **JX Nippon Mining & Metals**
- **Metallo Belgium**
- **nanoRanch**
- **Olympus Scientific Solutions Americas**
- **SMS Group**
- **Steinert**
- **Surface Combustion**
- **Tianqi Lithium**
- **Umicore**
- **U.S. Army Research Laboratory**

## **As a CR<sup>3</sup> member your company...**

- **submits and votes on research projects undertaken annually by CR<sup>3</sup>**
- **networks with global industry leaders**
- **has royalty-free IP rights to pre-competitive research**
- **may opt to sponsor company-proprietary research that remains exclusive**
- **has access to findings from large-scale projects funded by the U.S. government or foundation grants**



## **As a CR<sup>3</sup> member your company...**

- **can recruit top students from various engineering disciplines**
- **has access to all (past and current) CR<sup>3</sup> technical reports and process data**
- **membership fee is used for research expenses only without any institutional overhead**
- **has access to characterization facilities at all member institutions**
- **can consult CR<sup>3</sup> faculty, which helps members get timely solutions to factory floor problems without additional cost**
- **can sponsor student projects (senior thesis) and industrial internships**

## **As a CR<sup>3</sup> member your company...**

**Can work with sister centers, such as:**

- **Advanced Casting Research Center (ACRC) and Center for Heat Treating Excellence (CHTE) at WPI**
- **Kroll Institute for Extractive Metallurgy at CSM**
- **EIT-KIC Programs at KU Leuven and**
- **Research into Artifacts – Center for Engineering at Univ. of Tokyo**

**to broaden your understanding of research in recycling at partner universities.**



**2010-2016**

## **Projects:**

- **22 Completed Research Projects**
- **10 Current Research Project**
- **1 Project to begin in July, 2017**

**Patents: Provisional and full patents granted: 7**

**Students Graduated & Placed: 14**

# ***Our Achievements***

**CR<sup>3</sup>** Center for Resource  
Recovery and Recycling

**2010-2016**

## **Publications:**

- **Journals: 40**
- **Conference proceedings: 30**
- **Conference presentations: 60**

**Journal Launched:** Journal of Sustainable Metallurgy (Springer)

## **Publicity & Promotion:**

- **Website, e-mail, marketing and industry press**

## **Professional Partnerships:**

- **TMS – REWAS, Engineering Solutions For Sustainability**
- **KUL – Bauxite Residue Valorization**

## **Completed Research Projects**

- **Development of Aluminum-Dross Based Materials for Engineering Application (2011)**
- **Physical and Chemical Beneficiation for Recycling of Photovoltaic Materials (2011)**
- **Recovery of Rare Earth Metals from Phosphor Dust (2011)**
- **Recycling of Bag-House Dust from Foundry Sand (2011)**
- **Molten Metal Compositional Sensing to Enhance Scrap Recycling (2012)**
- **Rare-Earth Recovery from Magnets, Catalysts, and other Secondary Resources (2012)**
- **Resource Recovery and Recycling from Shredder Residue in North America (2012)**

## **Completed Research Projects**

- **Recovery of Eu/Y from Phosphor Dust (2013)**
- **Conditioning of Machined Chips (2013)**
- **Beneficiation of Flat Panel Functional Coatings (2013)**
- **Metal Recovery via Automated Sortation (2013)**
- **Recovery of Value-Added Products from Red Mud and Foundry Bag House Dust (2013)**
- **Dezincing of Galvanized Steel (2014)**
- **Development of a Novel Recycling Process for Li-Ion Batteries (2014)**

## **Completed Research Projects**

- **Fundamental Study of Lithium Ion Battery Recovery (2014)**
- **Magnet Separation Technologies for Recycling (2015)**
- **Recovery of Zinc and Iron from EAF Dusts (2015)**
- **Synthesis of Inorganic Polymers from Metallurgical Residues (2015)**
- **Recovery of Valuable Metals from Fines (2016)**
- **Value Recovery from Mining Wastes (2016)**
- **Battery Design for Disassembly in Support of Materials Reuse (2016)**
- **Rare Earth Metals Recovery from Bauxite Residue (2016)**

## **Current Research Projects**

- **Hydrometallurgical Treatment of e-Scrap (Jul 2017)**
- **Online Slag and Bullion Analysis by LIBS (Dec 2017)**
- **Recovery of Valuable Metals from Flue Dust and Other Fines from Mechanical Treatment of e-Scrap (Dec 2017)**
- **Reuse Opportunities for Bauxite Residue (Dec 2017)**
- **Electro-Oxidation of Metals & Inorganics (begins July 2017)**

## **Current Research Projects**

- **Scrap Characterization (May 2018)**
- **Pretreatment Processes of Waste Printed Circuit Boards (June 2018)**
- **Vacuum Distillation of Complex Lead Bullion (Sept. 2018)**
- **Waste Water Treatment Sludge & High Value Grinding Swarf Recycling (Sept. 2018)**
- **Separation of Eu and Y from Phosphor Dust (Sept. 2018)**
- **Innovative Refining Technologies for Sb Recovery (Dec 2018)**



## **Research Funding 2010-2016**

**Industry membership: 4.5 million USD**

**Federal funding: 1.2 million USD** (NSF to WPI/CSM)

**Leveraged federal funding: 1.5 million USD**

# ***Our Achievements***

**CR<sup>3</sup>** Center for Resource  
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## **Companies Launched**

**Kinetic Batteries, LLC**



**Kinetic Batteries**

**Battery Resources, LLC**



## **Employers of Graduates**

- **Battery Resourcers**
- **Boston Power**
- **Copper Consulting of Anaconda**
- **FTI Consulting**
- **Gopher Resources**
- **Honeywell**
- **Radikal Therapeutics**
- **Severstal Steel**
- **State Development and Investment Corporation of China**
- **Umicore**
- **UTRC**
- **VJ Technologies**
- **WPI**

***Join us...***

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# **Spring 2017 Center Industrial Advisory Board (IAB) Meeting**

**University of Tokyo**

**Hongo Campus, Tokyo, Japan**

**May 23-24, 2017**

**For information visit:**

**<http://wpi.edu/+CR3>**