Challenges in closing the loop for special metals

Christina Meskers
MMTA's International Minor Metals Conference

Umicore Precious Metals Refining
London 26 - 28 April 2010
Agenda

I Introduction

II Why should we bother?

III Challenges in closing the loop
I Introduction
Today, our company is...

- … one of the world’s biggest suppliers of automotive catalysts for passenger cars

- … is the world’s largest recycler of precious metals from old mobile phones, laptops, electronic scrap or spent catalyst material

- … a world leader in the production of key materials for rechargeable batteries used in laptops and mobile phones

- Umicore’s germanium substrates for high-efficiency solar cells are used in the bulk of the satellites launched today
Umicore today: global footprint

<table>
<thead>
<tr>
<th></th>
<th>1999</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenues</td>
<td>€865m</td>
<td>€1,723.2m</td>
</tr>
<tr>
<td>Number of sites</td>
<td>32</td>
<td>85</td>
</tr>
<tr>
<td>Workforce</td>
<td>8,065</td>
<td>13,720</td>
</tr>
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</table>
Where can Umicore play a role in Cleantech?

Creating value by reducing the use of rare and valuable materials

**Less is More**

**Energy Solutions**
Materials for energy storage and sustainable energy production

**Recycling Solutions**
Addressing resource scarcity and emissions by closing the materials loop

**Environmental Solutions**
Technologies to mitigate environmental impacts
## Recycling solutions in Cleantech

<table>
<thead>
<tr>
<th>Product</th>
<th>Product</th>
<th>Recycling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germanium substrates (Space &amp; CPV)</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Automotive catalysts (PGM’s)</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>ITO / AZO targets</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Selenium, Indium, Tellurium, Gallium*</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Rechargeable batteries</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Electronics (contacts, solders…)</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Platinum components and catalysts for glass industry</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Jewelry precious metal alloys</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Ag</td>
<td>✔️</td>
<td>✔️</td>
</tr>
</tbody>
</table>

* unrefined Ga product
Growth investments

Energy solutions > Rechargeable batteries

Li-Ion cathode materials
- Capacity & capability expansion in Cheonan, South Korea
- Completed

Li-Ion cathode precursors & materials
- Production plant in Jiangmen, China
- Completed
Growth investments
Energy solutions > Photovoltaics

Germanium substrates for high-efficiency cells
- Production plant in Quapaw, US
- Plant constructed, under qualification

Rotary sputtering targets for thin film cells
- Development lab in Balzers, Liechtenstein and Providence, US

Recycling service for thin film cell production waste
- Recycling plant in Hoboken, Belgium
Growth investments

Recycling solutions

Jewellery and electroplating materials
- Recycling and production facility in Foshan, China
- Completed

Battery recycling
- Pilot line in Hoboken, Belgium
- Initial investment of €25m approved
<table>
<thead>
<tr>
<th>Metal</th>
<th>Capacity</th>
<th>Quality</th>
<th>Forms</th>
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</thead>
<tbody>
<tr>
<td>Tellurium</td>
<td>150 t/y</td>
<td>2N5</td>
<td>powder, ingots</td>
</tr>
<tr>
<td>Indium</td>
<td>50 t/y</td>
<td>4N, 4N8</td>
<td>ingots, shots, shells</td>
</tr>
<tr>
<td>Selenium</td>
<td>600 t/y</td>
<td>2N5, 3N, 4N5, 5N, 5N+</td>
<td>powder, shots</td>
</tr>
</tbody>
</table>
Best available technology focussed on secondary precious metal materials

**Feed: 350,000 mt complex PM materials**

Recovered metal value (2007):
2,600 M$ PM, other metals 400 M$

PM recovery yield > 95%

**Highest environmental standards:**
ISO 14001 & 9001, OSHAS 18001

Minimizing waste < 5%

> 1 billion € investment
II Why should we bother?
Are we behaving just like this caterpillar?

The very hungry caterpillar by Eric Carle
Increase in demand started 2-3 decades ago

Mined in the last 30 years compared to mined since 1900 in %

Challenges in closing the loop for special metals
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# Competing for the same metals

<table>
<thead>
<tr>
<th></th>
<th>In</th>
<th>Ga</th>
<th>Se</th>
<th>Te</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photovoltaics</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Medical/dentistry</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Magnets</td>
<td>×</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Other alloys</td>
<td>✓</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Metallurgical</td>
<td>×</td>
<td>×</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td>Glass, ceramics, pigments</td>
<td>✓</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Batteries</td>
<td>✓</td>
<td>×</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Catalysts</td>
<td>×</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Nuclear</td>
<td>✓</td>
<td>×</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Solder</td>
<td>✓</td>
<td>×</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Electronic</td>
<td>✓</td>
<td>✓</td>
<td>×</td>
<td>✓</td>
</tr>
<tr>
<td>Opto-electric</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Grease, lubrication</td>
<td>×</td>
<td>✓</td>
<td>×</td>
<td>×</td>
</tr>
</tbody>
</table>
Drivers for recycling

**Policy - Legislation**
Can support recycling even if volume and environment driver are not present. The long term and strategic aspects are society driven.

**Value**
There is money to be made from recycling. For example: gold jewellery, silverware, automotive catalysts, …

**Long term sustainability**
Resource conservation
Secure & long-term access to resources

**Environment**
There is a threat to the environment, health or safety. For example: hydrocarbons, asbestos, …

**Volume**
The volume is so big it cannot be “left on the street”. For example: household waste, construction waste, cars, …
III Challenges in closing the loop

a primary supply
b ITO recycling
c CIGS recycling
Challenges in closing the loop for special metals

Life cycle

End-of-Life → Residues

New scrap → Raw materials production

from concentrates, ores

Metal & compounds → Residues

Raw materials production → from industrial materials

Use

Product manufacture

Use → Residues

End-of-Life

Residues

Natural resources

New scrap → Residues
Reality

Product manufacture

Use

End-of-Life

Raw materials production

New scrap

Metal & compounds

Natural resources

Reality

Residues

Use

End-of-Life

Residues
Coupled production affects primary supply

- Increased demand can only be met if demand for carrier metals rises accordingly.
- This will place an absolute cap on total availability in terms of reserves and primary supply.

C. Hagelüken, CEM Meskers: Complex life cycles of precious and special metals in Linkages of Sustainability. T Graedel and E van der Voet (eds), 2010
Challenges in closing the loop for special metals 21

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Challenges in primary supply

1. Mining
   - Production of special metals is coupled.
   - Losses in tailings

2. Smelting
   - Losses in parent metal, slag, other residues.
   - Smelter has to be equipped for effective special metal recovery OR
   - By-products of smelter are sent to specialized treatment facility for recovery of precious & special metals ⇒ Umicore

3. Refining
   - Logistics and refining processes will affect availability of high purity minor metals
Indium Tin Oxide recycling
Indium Tin Oxide

**Production from concentrates, ores**

**Natural resources**

**by-products**

Umicore Thin Film Products

**ITO target**

PV or LCD display manufacturer

**spent target**

End-of-Life

Use

Lost in other material cycles

Residues

Challenges in closing the loop for special metals

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The main objective of pre-processing is to effectively and efficiently separate the goods to be recycled into fractions that can enter existing and sustainable mainstream recovery processes.
Challenges in the ITO cycle

- Indium is supplied via processing of by-products of the non-ferrous industry
- Indium is used for the production of ITO targets
- Spent targets are recycled into targets

1. Manufacturer
   - Losses of indium in other waste or residue streams
   - Recycling of targets works well because of their value

2. End-of-Life product recycling
   - Small products with LCD display are very difficult to collect
   - EU WEEE directive pushes recycling of LCD display
   - Dismantling & separation technology is recently developed, off the shelf not possible due to Hg in backlights
   - Umicore’s role in recycling In-containing fractions under investigation
CIGS recycling
CIGS

Production from concentrates, ores

Natural resources

Production waste

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by-products

Copper, indium, gallium, selenium

PV manufacturer

End-of-Life

CIGS module in use

Residues

under investigation

PV manufacturer

End-of-Life

CIGS module in use
CIGS module in use

Production from concentrates, ores

Natural resources

by-products

Production waste

under investigation

PV manufacturer

Copper, indium, gallium, selenium

Residues

End-of-Life

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PV manufacturer

Residues

CIGS module in use
CIGS production waste recycling

CIGS production scrap → umicore → Cu, In, Ga, Se
Challenges in the CIGS cycle

Production wastes
- Umicore has closed the cycle for production wastes from sputtering and evaporation chambers
- Cu, In, Ga and Se are recovered for use in the PV or other industries

End-of-Life product recycling
- End-of-life products are hardly available
  - CIGS is a new technology and product life time is long
- Recycling driver is likely to be “volume” combined with a societal need
- Technologies for End of Life and recycling are under development
- Appropriate business models need to be developed too
Closing remarks

- Vision burden ⇒ opportunity
  ⇒ *new business models to increase collection*

- Attitude waste management ⇒ resource management
  ⇒ *comprehensive collection plus stop of dubious “waste” exports*

- Objective focus on mass ⇒ focus on quality and specific substances
  ⇒ *system approach and prioritisation*

- Practice traditional business ⇒ high-tech recycling
  ⇒ *recycling is a clean future technology so adapt structures accordingly*

*For future technologies (PV, EV/HEV, FC, …) recycling strategies need to be developed at an early stage!*
Thank you

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