Investor site visit
Burlington automotive catalysts plant

Burlington, 22 February 2013
Automotive Catalysts
At a glance

Complete automotive catalyst system offer for reduction of exhaust gas emissions

One of 3 world leaders
- 30% market share in light duty market (passenger cars)
- Establishing position in heavy duty segment

R&D intensive business
with R&D expenditure > 10% of revenues (ex PMs)

Globally positioned
- 5 regional R&D/test centres
- 11 plants, on 5 continents
What is an automotive catalyst?

Combustion engines produce toxic emissions due to incomplete combustion of fuel and the generation of by-products.

Automotive catalysts are needed for reducing these toxic emissions.

Legislation enforces this by setting emission limits for vehicles.

- **Non-toxic by-products**
  - Carbon Dioxide (CO$_2$)
  - Water (H$_2$O)
  - Nitrogen gas (N$_2$)

- **Toxic pollutants**
  - Carbon Monoxide (CO)
  - Hydrocarbons (HC, NMOG)
  - Nitrogen Oxides (NO$_x$)
  - Particulate Matter (PM)

- **Canning**
  - Metal housing
  - Insulation

- **Substrate** (ceramic or metallic)

- **Washcoat**
  - (Inert) fine particulate support materials (Al, Ce, Zr, …)
  - Supporting precious metals (Pt, Pd, Rh)

*Materials for a better life*
What is an automotive catalyst?

**Substrate**
(Substrate Manufacturer)

**Catalyst**
(Umicore)

**Catalytic Converter**
(Canner)

Internal surface area of 1 substrate = the size of a typical office

Internal surface area of 1 catalyst brick = the size of ~3 football fields
Business model

Development phase
- Catalyst & emission system architecture
- Contract negotiation

Production phase
- Substrate manufacturer
- Catalyst manufacturer
- Canner
- Car/engine manufacturer
- End consumer

End-of-life phase
- Recovery of precious metals from automotive catalysts (in business unit PMR)

materials for a better life
Products & applications

Supply

- Primary sources
- Secondary materials
- End-of-life materials e.g. spent autocats

Metal

- Platinum
- Palladium
- Rhodium

Product

- 3-way gasoline catalyst systems
- Diesel oxidation catalyst
- Diesel particulate filters
- NOx storage catalysts
- SCR catalyst systems

Application

- Light duty gasoline engines
- Lean burning gasoline engines
- Light duty diesel
- Heavy duty diesel and CNG engines

Market

- Passenger cars
- Transport Industry
- Non-road Applications

Recycling of autocats and other secondary materials in BU PMR
Business drivers

Growing global light duty vehicle production

- Light duty vehicles (LDV): passenger cars, SUVs and light trucks
- Heavy duty diesel (HDD): trucks and buses
- Non-road applications

Emission legislation and air quality standards are becoming more stringent in developed and emerging markets

CO₂ emission reduction

- Impacts engine complexity and fuel types used in different regions
- Determines choice of powertrain
Global light duty vehicle production outlook

Established Markets

Source: Umicore estimate based on external data sources

Emerging Markets

Source: Umicore estimate based on external data sources
Global powertrain development
Internal Combustion Engine (ICE) remains dominant

Car production
[M vehicles]

Contains combustion engine
Requires catalyst system

Source: Umicore estimate based on external data sources
Challenging CO₂ emission targets pushes advanced engine configurations

### Advanced ICE configurations
- Down-sized turbo-charged gasoline
- Gasoline direct injection
- Lean burning gasoline engines
- Diesel
- (Flex fuel)

### Electrification of the vehicle
- Start-stop mechanism
- HEV: Mild HEV → Full HEV
- PHEV: Parallel → Range extender
- EV: BEV → FCEV

Requires more complex emission control catalyst solutions
Requires larger battery and still automotive catalyst (except EV)
Umicore’s product offer covers all powertrain possibilities

<table>
<thead>
<tr>
<th></th>
<th>ICE</th>
<th>HEV</th>
<th>PHEV</th>
<th>EV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal</td>
<td>Start-stop</td>
<td>Mild</td>
<td>Full</td>
</tr>
<tr>
<td>Emission control catalyst</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td>Relative size</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
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<tr>
<td>Relative complexity</td>
<td>+</td>
<td>+</td>
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<td>++</td>
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| Battery | | | | | |
|--------|---|---|---|---|
| Relative size | + | + | ++ | ++ | +++ | + |
| Relative complexity | + | ++ | +++ | + | ++ | + |

<table>
<thead>
<tr>
<th>Fuel cell</th>
<th>No fuel cell</th>
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<tbody>
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Global emission legislation present in most regions and becoming more stringent

- EU regulation
- EU inspired regulation
- US regulation
- Japanese regulation
- No legislation
Umicore’s global leadership position

Regional positions
- **Market leader** (#1 or #2 position)
- **Smaller player** (distant #3)

Circles indicative of 2012 light duty vehicle production volumes (≠ catalyst revenues)
Umicore’s global footprint in automotive catalysts
Automotive Catalysts in North America
Moderate growth of light duty vehicle production expected in North America

Production in 2016 expected to reach record 2000 level

Corporate Average Fuel Economy (CAFE) regulation

- 35.5 mpg (miles per gallon) to be reached by 2016 (now 23.1 – 27.5)
- From 2017 to 2025 fuel economy will increase to an average of 54.5 mpg
- CAFE regulation pushes towards more efficient engine types
  - Focus on turbocharged gasoline direct injection
  - Diesel market acceptance is increasing gradually

New Emission legislation

- EPA Tier 3 is currently under review at the OMB
- CARB LEV (Low Emissions Vehicle) III cuts emissions by 50% of current most stringent SULEV legislation
- Green House Gas Standards (GHG) includes standards for secondary emissions ($N_2O$, methane and particulates)

Source: Umicore estimate based on external data sources
Gradual implementation of LEV III (SULEV20) emission standards to be reflected in vehicle fleet

![Sales share to be reached to meet emission norms](image)

- NMOG: Non-Methane Organic Gases

Source: CARB 2010
Various emission categories require more and more advanced catalyst technologies

<table>
<thead>
<tr>
<th>System requirements</th>
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<tr>
<td><strong>ULEV</strong></td>
</tr>
<tr>
<td>• Low light-off</td>
</tr>
<tr>
<td>• On-board diagnostics</td>
</tr>
<tr>
<td><strong>SULEV</strong></td>
</tr>
<tr>
<td>• Increased Hydro Carbon (NMOG) performance</td>
</tr>
<tr>
<td>• Robustness over lifetime</td>
</tr>
<tr>
<td><strong>SULEV20</strong></td>
</tr>
<tr>
<td>• Combined NMOG/NO\textsubscript{x} performance</td>
</tr>
<tr>
<td>• Stricter particulate mass standards</td>
</tr>
<tr>
<td>• Durability increased to 150,000 miles</td>
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Umicore’s market position in North America

CARB LEVIII and EPA Tier III pending legislation offers catalyst growth opportunities

Umicore has a leadership position in the North American market

- Catalyst production in North America started in 1983
- Acquisition of Delphi catalysts activities in 2007

Strong technology portfolio and system knowledge available to support the market requirements

- State of the art technology development centre in Auburn Hills to manage local development programs
- R&D centre in Tulsa to support local engine development
Automotive Catalysts
North America footprint

**Auburn Hills, Michigan, USA**
- Headquarters AC-Americas
- North American Technical Center

**Burlington, Ontario, Canada**
- Catalyst Production since 1983
- Precious Metal Salt Production
- North American Prototype Lab

**Tulsa, Oklahoma, USA**
- Catalyst Production since 1974
- North American Satellite R&D
Quality, health, safety & environment

All three of our North American sites are certified to external standards

- Quality: ISO / TS 16949
- Environment: ISO 14001
- Health & Safety: OHSAS 18001
Generalized Process Flows
Generalized process flow for precious metal solutions

1. Receipt of sponge at vault
2. Verify weights & purity
3. Transfer pgm to salt production
4. Digestion of pgms
5. Sampling & quality release
6. Transfer PM solution to Vault
7. Further processing of pgm solutions
8. Sampling & quality release
9. Transfer PM solution to vault
Generalized process flow for automotive catalysts

Chemical Raw Materials

Pure Pt, Pd & Rh Metal

Pt, Pd & Rh Solutions

Substrates or Filters

Catalyst Washcoat Slurries

Catalyst Coating

100% piece control

Drying / Calcining

For Multiple Pass Products

Labeling

Catalysts for Delivery to Customers

materials for a better life
Degussa Canada Ltd – Import/distribution business for chemicals & fabricated precious metal products

1979
First phase of the Canadian Catalyst Manufacturing Plant + Precious Metal Refinery Sampling Facility

1983
Major expansion of Burlington Catalyst Plant and construction of Gold Refinery

1986
Closure of Gold Refinery and creation of our NA Automotive Catalysts Management Team

1991
Major Catalyst Plant Expansion

2001/02
Umicore Acquisition

2003
Diesel Catalyst Expansions

2005/06
Line Up-grades

2009/10

Materials for a better life
Burlington operations scope

Production operating on a 24/7 schedule

- Emission control catalyst production
  - Gasoline
  - Light-duty diesel
  - Heavy-duty diesel
- Precious metal solution production

North American Prototype / sample production facility

AC-North American Customer Service & Accounts Receivable

Administrative Office – Umicore Shokubai USA, Inc.