PVD coating technology

Partner for the minting industry

- Miba Facts & Figures
- Work safety advantages
- Lifetime advantages
- Other applications
Miba Facts & Figures
Global company

Sales in EUR million

<table>
<thead>
<tr>
<th>Year</th>
<th>2009-10</th>
<th>2010-11</th>
<th>2011-12</th>
<th>2012-13</th>
<th>2013-14</th>
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<td>312</td>
<td>437</td>
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Employees

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<tr>
<th>Year</th>
<th>2009-10</th>
<th>2010-11</th>
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<th>2012-13</th>
<th>2013-14</th>
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<td>Value</td>
<td>2,585</td>
<td>3,478</td>
<td>4,300</td>
<td>4,386</td>
<td>4,670</td>
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By Market

Europe 63%
NAFTA 19%
Asia 15%
Others 4%

By Division

Bearing Group 30%
Friction Group 22%
New Technologies Group 8%
Coating Group 2%
Sinter Group 38%
PVD coating technology

Working safety aspects of the PVD coating vs. electroplating technology
Dies coating
Electroplating versus PVD coatings

Electroplating:
- “wet” and dirty process
- Hexavalent Chrome issue in plating process
- High working security regulations
- Difficult peripheral installation

- “dry” and clean process
- Big flexibility regarding coating materials
- Low working security regulations
- Easy installation in existing production area
REACH:

• Registration of chemicals produced more than 1 ton/year
• Evaluation
• Autorisation
• Chemicals

Controlled by European agency ECHA based in Helsinki

REACH 2018 – Annex 17 / 18
• Possibility of ban of Hexavalent Chromium of production in Europe
Consortium existing to complain against REACH 2018 regulation

- 0 Chrome producers within Europe
- 10 Import companies, with Production sites outside Europe
- 20 companies production of surface-treatment solutions
- > 2000 users in surface-treatment segment, also mints represented
- > 1.0 articles of hardchromium and passivated articles
• Reacts a strong acid
• Cr (VI) is absorbed by humans either through oral or dermatological routes.
• It is toxic and carcinogen due to its high oxidation potential and a structural similarity of chromate with sulfate, allowing the chromate to penetrate sulfate channels in cell membranes.

• The lethal oral dose is **50-60mg/kg body weight**.
**Leather goods:**

5. Leather articles coming into contact with the skin shall not be placed on the market where they contain chromium VI in concentrations equal to or greater than 3 mg/kg (0,0003 % by weight) of the total dry weight of the leather.

6. Articles containing leather parts coming into contact with the skin shall not be placed on the market where any of those leather parts contains chromium VI in concentrations equal to or greater than 3 mg/kg (0,0003 % by weight) of the total dry weight of that leather part.
Hexavalent Chromium
Reasons for alternative processes

- Improving the result of the existing solution
- Preventing employees of handling harmful substances
- Facilitating the coating process
- Better Lifetime of the minting dies
- Improving the quality of the minted product
- Avoiding legal issues
PVD coating technology

Advantages of PVD Coatings

- Hardness
- Friction coefficient
- Lifetime
- Coin quality
PVD Coatings

Hardness

- Hardness can be more than double depending on the coating
- Hardness can be adapted according to the application
- Flexibility of elements and parameters used for coating with direct effects on hardness

![Hardness Comparison Graph]

Average values
Graph courtesy of:
Toshi Murata of Japan Mint:
The shape of a scratch after 1,000 stampings:

- **PVD (RCM)**:
  - Length: 75 µm
  - Width: 4 µm

- **Cr (BRM)**:
  - Length: 90 µm
  - Width: 5 µm

- **Cr (JPN)**:
  - Length: 84 µm
  - Width: 4 µm

Depth measurements:
- **PVD (RCM)**: Depth: 0.2 µm
- **Cr (BRM)**: Depth: 0.6 µm
- **Cr (JPN)**: Depth: 0.4 µm

Graph courtesy of: Toshi Murata of Japan Mint: Report of Joint project Japan Mint, Royal Canadian Mint, Royal Mint UK, under Mint Directors Technical Committee, May 2008
PVD Coatings

Lifetime on RCM Mint circulation coins

Circulation Coin Production

- Die Life of Die Used for Small Circulation Nickel Plated Coins:
  - 280,000 for Obverse; 340,000 for Reverse
- Die Life of Die Used for Larger Nickel Plated Coins
  - 614,000 Obverse; 475,000 for Reverse
- This is a 20% increase in die life compared with arc
• Die Life of Die used for Circulation Nickel Plated Coins:
  • 140,000 for Obverse; 800,000 for Reverse
• Some of the reverse dies even performed up to 3,000,000 coins
PVD Coatings
Quality / handling amelioration Morocco Mint

- Lifetime
- Surface quality / shininess
- Higher machine availability / uptime
- No environmental concerns
- Working safety massively ameliorated
PVD Coatings
Example of a Coating Sequence

- **Substrate** (AISI M42 grade HSS, 1200 grit finish)
- **0.2 µm Cr bonding layer**
- **0.3 µm CrTiN graded layer**
- **4 µm nanoscale CrTiN multilayer, 10nm< Λ<15nm, individual CrN layers ~ 6.0nm**
PVD Coatings
Smooth coating

Coating Surface

Substrate Surface

Micrograph courtesy of:
Prof. Derek Arnell and Dr. Robin Bates (Salford University)
Dr. Chris Smith and Dr. Kevin Baldwin (QinetiQ)
PVD Coatings
Smooth coating - examples

Comparison – Die without coating – Chrome coating – PVD coating

=> PVD coating follows 1:1 the relief of the die (no filling up, even of defects)
PVD Coatings
Minting results on Silver proof coin 999 – 3 strikes – 33 mm

<table>
<thead>
<tr>
<th>Item</th>
<th>Step1 (~500 coins)</th>
<th>Step2 (~1000 coins)</th>
<th>Step3 (~1500 coins)</th>
<th>Step4 (~2000 coins)</th>
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- Starbust is starting at 1500 coins*
- Brightness excellent
- No bad spots

* Result with conventional technique was here 100 coins
PVD Coatings

Benefits

- Coin quality is improved
- Extremely decreased the problemacy of star bust
- Overall average die life increase of 3 times
- Elimination of all Hexavalent Chromium from die production facility
Benefits

- Finishing of coated die is smoother, no post-coating polishing needed
- The coating can be stripped for rework when required
- Hardness of die nearly tripled
- Low temperature deposition (lower than 150°C) opens up numerous options in the choice of die material.

Coin produced using CrTiN coated die, > 7000 stampings with no scratches or defects & still in operation
PVD coating technology

Other applications

- Colour coatings
- Precious metal coatings
PVD Coatings
Range of elements which can be sputtered

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As a major constituent
As a minor component
PVD Coatings
Precious metal coatings - Numismatic applications

• Gold / Silver / Platinum / Palladium…
• Loading capacity for 40 mm coins: 280 pieces
• Material consumption for 1 micron coating thickness: ~ 6 gramm / 1 micron
• Adhesion layer CrN or TiN
• No environmental concerns
• Dry process
PVD Coatings
Coloured coatings – Numismatic applications

• Blue, Green, Red, Yellow
• Standard coatings TiN, ZrN
• Colour can be adapted due to:
  • Materials sputtered
  • Gas concentration
  • Other parameters
Close to our Customers
We are long-term Partner of our Customers

Main Brands automotive

Royal Canadian Mint, Royal Mint UK, Royal Australian Mint, Perth Mint, South African Mint, US Mint, Shenyang Mint, Shenzhen Mint, Pamp (CH), Bank al Maghrib (Ma), Münz-Prägstatt – Munich (DE)

In total 16 systems WW installed in the minting industry