H.C. STARCK

AMPERIT®
and
AMPERWELD®

Powders for
Surface Technology
and more…!

Hans Keller, May 2006, ITSC, Seattle
The History of H.C. Starck

Rhina plant of "Elektrochemische Werke Bitterfeld", around of 1913 - the very beginnings of the industrial commitment of Hermann C. Starck

Hermann C. Starck
(photographed in September 1967)
The modern world of H.C. Starck

- Electronics and Optics
- Hard Metals
- Ceramics and Surface Technology
- Chemical and Fabricated Products
# Facts about H.C. Starck

<table>
<thead>
<tr>
<th><strong>Founded by</strong></th>
<th>1920 in Berlin by Hermann C. Starck</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Legal form</strong></td>
<td>GmbH</td>
</tr>
<tr>
<td><strong>Nominal Capital</strong></td>
<td>42 million Euro</td>
</tr>
<tr>
<td><strong>Sales 2005</strong></td>
<td>920 million Euro (H.C. Starck Group)</td>
</tr>
<tr>
<td><strong>Number of employees</strong></td>
<td>3,437 worldwide</td>
</tr>
<tr>
<td><strong>Parent Company</strong></td>
<td>since 1986 Bayer AG, Leverkusen</td>
</tr>
</tbody>
</table>

May 2006
The international group of H.C. Starck

H.C. Starck GmbH
Goslar / Laufenburg / Leverkusen
Germany

H.C. Starck Inc.
Newton, MA., USA

H.C. Starck - V TECH Ltd.
Tokyo, Japan

H.C. Starck Thailand
Map Ta Phut, Thailand

H.C. Starck Canada
Sarnia / Ontario, Canada

H.C. Starck Ceramics
Selb, Germany

H.C. Starck Hermsdorf
Hermsdorf, Germany

H.C. Starck UK Ltd.
West Horndon / Calne, UK

H.C. Starck Liaison Office
Sheffield, UK

H.C. Starck Liaison Office
Paris, France

H.C. Starck Liaison Office
Mijdrecht, Netherlands

H.C. Starck Liaison Office
Gothenburg, Sweden

H.C. Starck Liaison Office
Singapore

H.C. Starck Liaison Office
Milan, Italy

H.C. Starck Liaison Office
Shanghai, China

Agents in more than 30 countries
Production plants around the globe

North America
- Coldwater 135
- Cleveland 108
- Latrobe 38
- Calne 72
- East Rutherford 137
- Newton 320

Europe
- Goslar 1.304
- Selb 227
- Leverkusen 109
- Laufenburg 471
- Map Ta Phut 223

Asia
- Tokyo 120

Total Worldwide: 3,437
The organization of H.C. Starck

H.C. Starck GmbH
Executive Board

Corporate Staff Departments
MSÖ Marketing Services and Public Relations
RPV Law, Patents and Insurance
QM Quality Management

Business Groups
HMC Hardmetals, Mill Products and Catalysts
BPR Battery Products
EOP Electronic and Optic Products
CST Ceramic and Surface Technology
FPR Fabricated Products

Central Divisions
FE Research and Development
BW Business Management
MW Procurement
PT Production and Engineering
PS Human Resources
Markets we serve

- Metal-working Industry
- Aerospace Industry
- Electronics
- Mining Industry
- Chemical Industry
- Thermal Spraying
- Battery Industry
- Medical
- High Temperature Applications
- Automotive Industry
Our company has been certified according to DIN EN ISO 9001 and DIN EN ISO 14001 with all sites of H.C. Starck GmbH:

- In addition our Central Quality Control is accredited in compliance with DIN EN ISO IEC 17025:2000.

- We have also introduced QM processes which go beyond the requirements of DIN EN ISO 9001:2000 in those production facilities in which particularly sophisticated products are manufactured. Our QM system has been positively evaluated in audits conducted by customers that are OEMs or direct suppliers of the aircraft, automotive and aerospace industry requiring standards based on QS 9000/VDA 6.1/TS 16949 / AS 9001 etc.
H.C. Starck Laboratory Accreditation
Materials – Development – Solutions

Our concept to serve the market

- **Materials…**
  Stands for H.C. Starck’s material competence which is unique the world over and extends throughout the company both vertically and horizontally.

- **Development…**
  Stands for the innovation potential and expertise that makes us a driving force behind new products, applications and global markets.

- **Solutions…**
  Stands for the ability to support our customers with appropriate or even customized product solutions across their entire value chain.

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Business Unit Surface Technology

INDUSTRIAL SOLUTIONS

EVERYWHERE IN THE WORLD…!

AMPERIT® and AMPERWELD®
Powders for Surface Technology and more...

May 2006
Our global sales network

Benelux served by Flame Spray Technologies b.v.
Headquarter Germany

H.C. Starck GmbH
Head of Global Marketing and Sales, Laufenburg
hans.keller@hcstarck.com
Marketing, Laufenburg
joachim.beczkowiak@hcstarck.com
Sales, Goslar
matthias.fritsch@hcstarck.com
Technical Support, Laufenburg
stefan.zimmermann@hcstarck.com
Sales Offices Europe…

H.C. Starck GmbH
Germany, Goslar
birgit.beck@hcstarck.com

UK and Ireland, Sheffield
mike.thompson@hcstarck.com

Scandinavia, Gothenborg
kennet.almkvistl@bayermaterialscience.com

Italy, Milano
andreas.donati@bayermaterialscience.com

Flame Spray Technologies (FST) b.v.
Benelux, Duiven
m.zwetsloot@fst.nl

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Sales Offices North America

H.C. Starck Inc.

Cincinnati Office, West Chester, OH
james.ryan@hcstarck.com

Newton Office, Newton, MA
hamid.haider@hcstarck.com

Houston Office, Conroe, TX
alan.marshall@hcstarck.com

Coldwater Office, Coldwater, MI
scott.ohm@hcstarck.com
Sales Offices Japan and Korea

H.C. Starck Ltd.
Japan, Tokyo
hajime.nakadate@hcstarck.com

Bayer Korea Ltd. / Division H.C. Starck
South Korea, Seoul
gihong.park@bayer.co.kr
Sales Offices Asia/Pacific

Bayer (SEA) Pte. Ltd. / H.C. Starck
Singapore
kenny.wong@hcstarck.com

In China (中国) also:
SIGNAL HITEK, Shanghai
gxie@signalhitek.com
DENSE COAT, Beijing
amyyan@263.net.cn

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Our Technical Support
Providing Technical Expertise and more

A modern thermal spray laboratory and highly specialized metallographic laboratory combined with outstanding experience in many applications guarantee top-quality application engineering including:

⇒ Materials respectively coating recommendations
⇒ Coating quality analysis
⇒ Spray parameters
⇒ Trouble shooting and advices
Our Technical Support
Application Spray and Metallographic Laboratory

Equipment includes:

⇒ Cold Spray
⇒ HVOF (DJ Hybrid, Top Gun)
⇒ Plasma (F4, 7/9 MB)
⇒ Wear Test
⇒ Corrosion Test
⇒ Cavitation Test
⇒ Bond Strength Test
⇒ Bending Test
⇒ Surface Roughness Test
⇒ Micro- and Macrohardness Test
Our Global Partner

Working close together

May 2006
Cold Spray Competence Group

Driving force for the future

H.J. Richter
Fluid dynamics
Fundamental research
Evaluation of applications
Support to industry

H. Kreye
Material science

P. Heinrich
Gas technology

P. Richter
Spray systems
Equipment

A. Eiling
Materials
Powder

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Materials  –  Solutions - Development

Unique in Breadth and Depth

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H.C. Starck
Empowering High Tech Materials
Inhouse production capabilities

Providing well-established and new production methods for state of the art materials:

- Atomization
- Agglomeration (Sintering)
- Sintering
- Fusing
- Cladding
- Blending
- Spheroidization

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Atomization

Vacuum

MCrAlYs

Inert gas

Ni-SF

Water

NiCr

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Agglomeration and/or Sintering

Agglomeration
ZrO$_2$-Y$_2$O$_3$

A + S
WC-Co

Sintering
WC-Co-Cr

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Fusing and Crushing

Fusing

Cr$_2$O$_3$
Cladding, Blending, Spheroidization

Cladding
Ni-Graphite

Blending
Mo-NiSF

Spheroidization
ZrO$_2$-Y$_2$O$_3$
Materials – Solutions - Development

Product Portfolio for AMPERIT® and AMPERWELD®

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Materials – Solutions – Development
AMPERIT® / Product Portfolio for Thermal Spraying

Carbides for wear resistance.

⇒ WC-Co
⇒ WC-Co-Cr
⇒ WC-Ni
⇒ WC-WB-Co (-Cr)
⇒ WC-CrC-Ni
⇒ WC-NiMoCrFeCo
⇒ Cr$_3$C$_2$-NiCr
⇒ Cr$_3$C$_2$-CoNiCrAlY
⇒ Mo$_2$C
⇒ TiC
Materials – Solutions – Development
AMPERIT® / Product Portfolio for Thermal Spraying

Oxides for wear protection, chemical resistance and heat protection.

⇒ Cr₂O₃
⇒ Cr₂O₃-TiO₂
⇒ Al₂O₃
⇒ Al₂O₃-TiO₂
⇒ TiO₂
⇒ Al₂O₃-ZrO₂
⇒ ZrO₂-Y₂O₃
⇒ Y₂O₃
Materials – **Solutions** – Development

AMPERIT® / Product Portfolio for Thermal Spraying

**MCrAlY**s as bond coat and as corrosion protection for high temperature applications.

⇒ NiCoCrAlY
⇒ NiCrAlY
⇒ CoNiCrAlY
⇒ NiCoCrAlTaReY
⇒ SV 20, SL 20, SH20, SVP 20
⇒ SV 30, SL 30
⇒ SL 349, SVP 349
⇒ Sicoat 2231, 2453, 2464
Materials – Solutions – Development

AMPERIT® / Product Portfolio for Thermal Spraying

Molybdenum for automotive applications.

⇒ Mo (low carbon)
⇒ Mo (high carbon)
⇒ Mo-Mo$_2$C
⇒ Mo$_2$C
⇒ Mo-NiSF
⇒ Mo-NiSF + hard particles
Other pure metals, alloys and blends.

⇒ W, Ta, Ti, Nb, Ni
⇒ Ni-Graphite
⇒ NiCr
⇒ NiAl
⇒ NiCrBSi
⇒ 316 L
⇒ Hastalloy
⇒ others on request
Materials – Solutions – Development
AMPERWELD® / Product Portfolio for Welding

AMPERWELD® powders.

⇒ Cast Tungsten Carbide
⇒ Macroline Tungsten Carbide
⇒ TiC
⇒ VC
⇒ Co-HFA NF 12
⇒ Ni-SA 625
⇒ Ni-SA 718
⇒ Co
⇒ W
⇒ Mo

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H.C. Starck
Empowering High Tech Materials
Materials – Solutions - Development

Examples of Areas of Applications

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Examples of Areas of Applications

➢ Aircraft Turbines…

Hot gas corrosion resistance for turbine blades through sprayed MCrAlYs alloy, thermal barrier coatings made of ZrO$_2$-Y$_2$O$_3$ for turbine parts in the highest temperature zones, wear resistance made by WC-Co and mechanical seals made of soft Ni-Graphite abradables for rotating parts.
Materials – Solutions – Development

Examples of Areas of Applications

➢ Automotive…

Mo + NiSF alloys on piston rings reduce wear in combustion engines. Wear resistant alloys for motor blocks made of light alloys.
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Examples of Areas of Applications

- **Paper and Printing Industry…**

  Ceramic or carbide wear resistant coatings for paper machine cylinders. Wear resistant and LASER engravable Cr$_2$O$_3$ coatings for printing rolls.
Examples of Areas of Applications

- **Hard chrome replacement**

WC-Co, WC-Co-Cr or Cr$_3$C$_2$-NiCr as replacements for galvanized hard chrome coatings for hydraulic cylinders.
Materials – Solutions – Development

Examples of Areas of Applications

➢ **Energy…**

Ni- and Co-based alloys as high temperature corrosion resistance and bond coat for thermal barrier coatings on stationary gas turbine blades.
Solutions – AMPERIT® 512

WC-Co 88/12 (low carbon) for sink rolls in steel industry

Modified WC-Co powder to increase the resistance against molten metal attack for Zn bath rolls designed for kerosine based HVOF systems.
Solutions – AMPERIT® 519
WC-Co 88/12 (fine carbide) for corrugating rolls

Fine carbides combined with fine grain sizes for smooth and thin as-sprayed coatings with high hardness to increase the lifetime of corrugating rolls.
Solutions – AMPERIT® 594

Cr$_3$C$_2$-CoNiCrAlY 75/25 agglomerated sintered

Modified Cr$_3$C$_2$-based powder for outstanding oxidation resistance and excellent wear and erosion protection.
Solutions – AMPERIT® 703

Chromium oxide H.P. sintered for printing rolls

High purity and metal free powder especially for anilox rolls and other applications with outstanding purity requirements.
Solutions – AMPERIT® 235
NiCrAl-Bentonite 20/80 for abradable coatings

Uniform cladded Bentonite for consistant sprayability and reproducible coating properties.
Solutions – AMPERIT® 832
ZrO$_2$-Y$_2$O$_3$ 93/7 agglomerated sintered for TBC coatings

Hollow spheric particles in agglomerated sintered form to combine the advantages of HOSP® powders with the high quality consistency and excellent melting behavior of agglomerated sintered powders.
Solutions – AMPERIT® 151

Tantalum Special Grade for Cold Spray

Special designed Ta refractory metal to spray very dense, high purity and oxygen-free coatings for petrochemical and electronical applications.
Solutions – Macroline Tungsten Carbide
Fused Tungsten Carbide for PTA-Welding

PTA Welding

Mining Industry
Solutions – Macroline Tungsten Carbide
Standard WSC or Macroline Tungsten Carbide (MTC)

Our standard

New MTC

The comparison

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Materials – Solutions - Development

Approvals for the Aircraft Industry

May 2006
H.C. Starck serving the aircraft industry

Our company serves globally the aircraft industry with state of the art materials on highest quality levels. With over 100 OEM approvals we are preferred supplier to:

⇒ OEMS
⇒ OEM Subcontractor
⇒ Independent aircraft repair shops
## GE Aircraft Engines (S-400)

### Table 1: Special Process Certification

<table>
<thead>
<tr>
<th>Process Code</th>
<th>Name of Process</th>
<th>Number of Process</th>
<th>Certification Approval &amp; Technical Environments Name for CE &amp; CE Marked</th>
<th>Additional Information</th>
</tr>
</thead>
</table>

**Footnotes:**

- All information is current as of **APRIL 2007**.
- Certification Authority: H.C. Starck GmbH
- Address: Kraftzentrum 75-91, 76842 Golling, Germany
- Phone: +49 7251 4751 0, Fax: +49 7251 4751 11

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**May 2006**

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**H.C. Starck**

**Empowering High Tech Materials**
Rolls Royce

Pratt & Whitney

Certificate of Approval

This is to certify that

H. C. Starck GmbH & Co. KG -
Goettingen, Germany

is an approved supplier for the scope specified:

Scope of approval:
- Manufacturing of components as specified in MIL-DTL-46158.

Approval number: 01926

May 2006

H.C. Starck

Pratt & Whitney

Materials Control
Laboratory Manual

Supplier Code: PW = 33937

APPLIES TO: Pratt & Whitney Group

1. GENERAL

1.1 Production and Experimental

1.1.1 This supplier has been authorized to operate under Pratt & Whitney (P&W) system of LABORATORY CONTROL, at SOURCE LOC, with regard to the testing and control of P&W's product and processes for orders placed by P&W or by P&W's customers, when such orders are executed in P&W's MCL Manual Section P-27 and/or P-64, Appendix 17, with the modifications or additional requirements documented. Supplier will also use this system of control on parts ordered by Pratt & Whitney Liquid Space Propulsion (LSP),

1.1.2 By acceptance of the terms of this Authorization, supplier certifies that all items supplied thereunder will conform to applicable drawings and associated requirements except as specifically stated in the corresponding Design Information. P&W will verify this with its acceptance inspection and in the event of non-conformance will notify supplier in writing within a reasonable time. Supplier will then take appropriate action to correct the non-conformance. Supplier's acceptance of this system of control indicates its commitment to supply items that conform to the requirements.

2. ADDITIONAL REQUIREMENTS

Lot acceptance tests shall be in accordance with P&W MCL Manual Section P-27.

NATURE OF CHANGE (IF ANY): Effective - H. C. Starck Berlin Facility closed and removed from this GIA.

*** End of Document ***
May 2006

Snecma Moteus

MTU Aero Engines

Certificate

We herewith certify that

H.C. Starck GmbH & Co. KG

Im Schleisee 78 - 91, 38642 Goslarn, Deutschland

Kraftwerksweg 3, 79725 Lauffen, Deutschland

Is registered as an approved supplier for metallic and ceramic thermal spray powder to MTU Aero Engines. This is in recognition of
demonstrated compliance with MTU requirements, Expires June 2006

H.C. Starck
Empowering High Tech Materials
H.C. Starck powders for aircraft industry

All powders for the aircraft industry are produced and documented according to DIN EN ISO 9001 and OEM specification requirements including:

⇒ **Documentation of raw materials:**
  - a detailed description of raw materials and sources is given.

⇒ **Documentation of production processes:**
  - a detailed description of production equipment and production settings / parameters is given.

⇒ **Documentation of powder analyses:**
  - all powder analyses results are documentated (electronic media).

⇒ **Powders:**
  - a powders sample of each produced lot is stored for a minimum of 5 years.

⇒ **Specific test reports:**
  - reports are filed and send with all materials
Examples of Specific Tests Reports
Materials – Solutions - Development

R + D work for Next Generation Materials…

May 2006
Powder development is production on a small scale. Standard powders are modified, or completely new powders are developed. The ability to modify standard powders ensures our customers fast and economic customization, as well as testing on a small scale. Innovative materials closely geared to market needs are also developed here, to offer our customers unique solutions to meet the most challenging requirements.
Materials – Solutions – Development

R + D work for next generation materials

Ultrafine carbides for high hardness and very good wear resistance.

May 2006
Materials – Solutions – Development

R + D work for next generation materials

Special matrix materials for excellent corrosion resistance.

<table>
<thead>
<tr>
<th></th>
<th>Polarization Curve in 5%-NaCl Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_{corr}$ ($\mu A/cm^2$)</td>
<td>$R_p$ (k$\Omega$ cm$^2$)</td>
</tr>
<tr>
<td>WC-Co</td>
<td>0.4</td>
</tr>
<tr>
<td>WC-Co-Cr</td>
<td>0.3</td>
</tr>
<tr>
<td>WC-NiMoCrFeCo</td>
<td>0.5</td>
</tr>
<tr>
<td>Cr3C2-NiCr</td>
<td>0.6</td>
</tr>
</tbody>
</table>
Materials – Solutions – Development

R + D work for next generation materials

Special composites for high temperature applications in steel industry.

\[
\text{Al}_2\text{O}_3\text{-MCrAlY}
\]

\[
\text{TiB}_2\text{-MCrAlY}
\]

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Materials – Solutions – Development

R + D work for next generation materials

Co and Ni are classified: harmful to health, carcinogenic, allergenic, Pollutant

New binder alloys for environmental and human protection using:

AMPERSINT® S.T.A.R.: high energy milled materials

AMPERSINT® COM: chemically precipitated

Development of less harmful binder alloys

⇒ (Partial) replacement of standard powders

May 2006
Our Competence
Providing Materials, Solutions and Developments

You are welcome to join us!

May 2006