CASE STUDY

Keep chrome, but lose the chemicals

How innovation has created sustainable, environmentally friendly coatings

Chrome symbolizes durability, prestige, and class. Appliances, cars, and kitchen and bath fixtures use chrome to signify value above and beyond ordinary plastic or raw metal parts. And for good reason: Chrome's basic metallic hardness and corrosion resistance add great durability to these products.

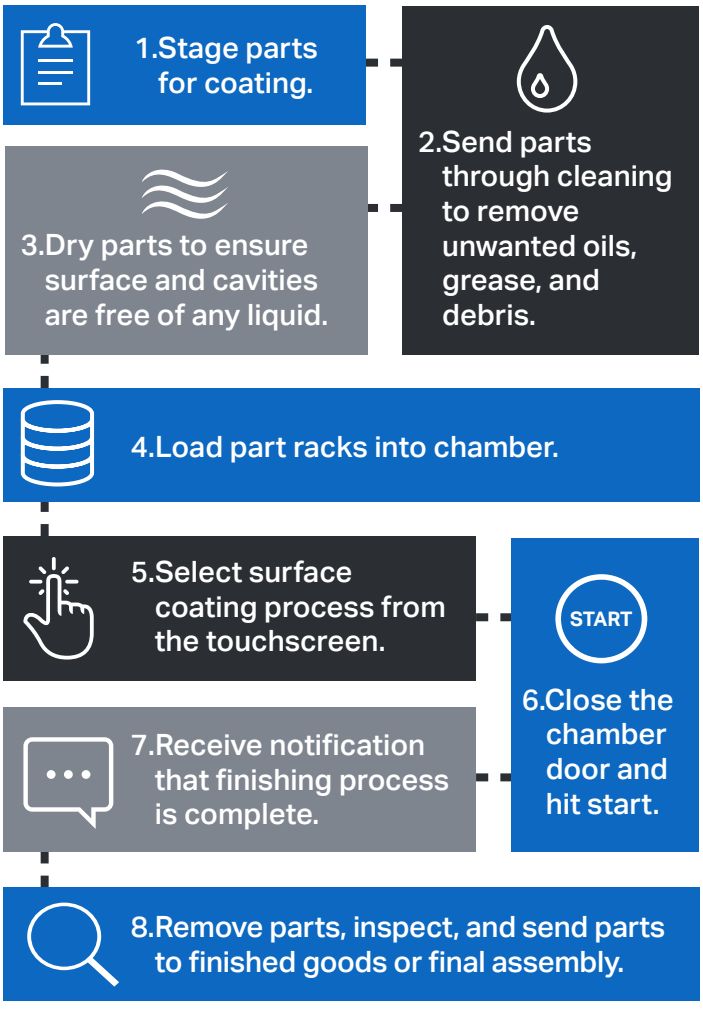
Since 2006, chrome electroplating (the traditional application method for chrome finishes) has been in a period of transition. A new regulatory framework from the U.S. Department of Labor's Occupational Safety and Health Administration (OSHA) established more stringent standards for exposure to liquid hexavalent chrome (Cr+6) electroplating dip tanks – chromium compounds are known to incorporate carcinogens CAS No. 18540-29-9 that can attack respiratory and skin tissues. The new law is driving the adoption of more sustainable coating techniques, since hexavalent chrome electroplating was an industry standard.

New regulations bring opportunity

Thanks to its ability to create hard, durable coatings, physical vapor deposition (PVD) is a popular choice for manufacturers that want to give their parts a chrome appearance and avoid costly compliance requirements. Compliance includes adhering to stringent regulations that aim to reduce the toxic effects on the waste stream as well as operational worker safety guidelines associated with electroplated chrome. Facing the high costs of complying with regulations for electroplating methods while still needing to deliver premium chrome finishes, companies are turning to PVD as a leading replacement technology.

Vapor Tech's efficient, cost-effective PVD processes combine metallic chrome with reactive gases to create

A simple, reliable, process that delivers high manufacturing yields across a range of materials, shapes, sizes, and durable metallic colors



a metal ceramic that is two- to three-times harder than plated chrome – providing the desired look and a longer lasting finish. The ability to create chrome finishes without plating chemistries offers opportunities for manufacturers to deliver chrome coatings while committing to an environmentally sustainable process.

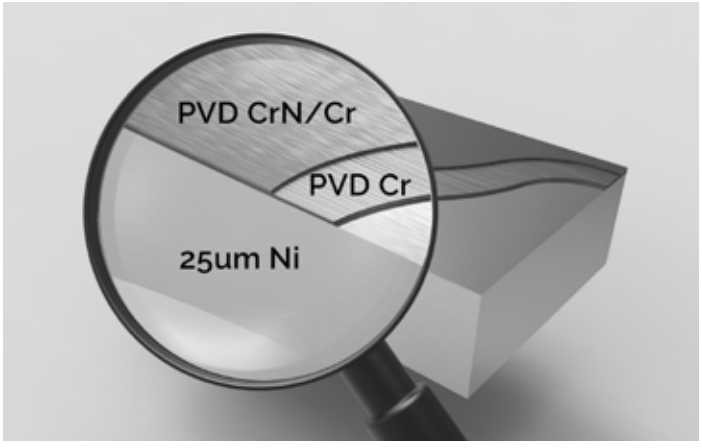
Vapor Tech's Low-Temperature Arc Vapor Deposition™ (LTAVD) and RAAMS™ processes represent an innovative leap over traditional PVD techniques. LTAVD works over a wider range of temperatures and uniformly coats products comprising diverse base materials. The RAAMS process takes advantage of a patented deposition technology to increase a coating's density to deliver a significantly harder, smoother, and tougher surface than is produced by traditional PVD techniques. Manufacturers with a Vapor Tech VT series or Cadence deposition system can process a wide variety of part sizes and shapes in the same system without any complicated control or mechanical hardware changes. This versatility has led companies to adopt Vapor Tech's deposition system and process technologies to deliver products with coatings that perform equally or superior to what legacy electroplating methods offer.

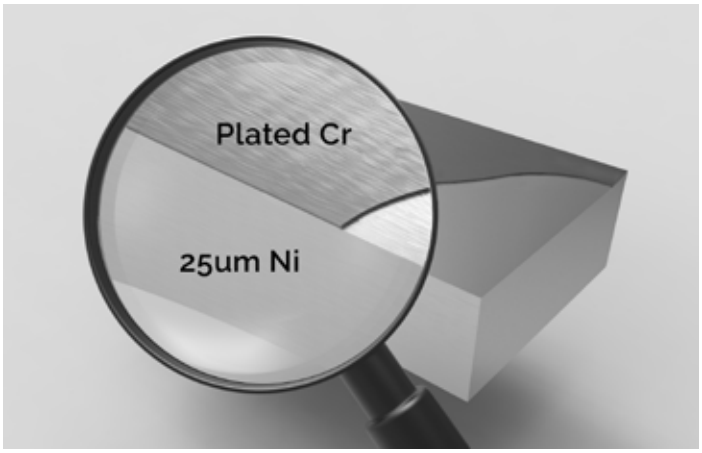
Testing validates coating durability and appearance

Deployed in leading factories and supply chains throughout Asia, North America, and Europe, LTAVD coatings are the established standard for automotive, plumbing, and many other products. Furthermore, the technical merits of the coatings have been empirically tested to strict industry standards (i.e. ASTM B 368, 537-70, 456).

In an experiment conducted by Vapor Tech, conventional electroplating methods were tested against LTAVD. The study compared the color, corrosion resistance, hardness, elasticity, and abrasion resistance of the two coatings. The results confirmed LTAVD as a substitute coating technique, as well as its superiority over traditional methods in several important categories. A range of coated sample steel plates were evaluated after exposure to the same elemental profiling. These samples differed in chrome application (hexavalent chrome electroplating vs. LTAVD) and their nickel undercoats; some LTAVD samples received base layers of pure chromium (Cr), while other received chromium nitride (CrN) in the beginning of the deposition process run.

- **Corrosion:** At a benchmark of 0.25 percent attacked area (rating 8), LTAVD-coated surfaces, on average, performed as well or better than chromium electroplated surfaces.
- **Color:** The color is virtually identical between the samples due to the fact that the top layer of both samples is pure Cr.
- **Hardness and elasticity:** Electroplated chromium tested to a hardness of 900 to 1,000 Hv, whereas the LTAVD samples were created to achieve 1,000 to 2,200 Hv (samples with a CrN base layer had the highest range).
- **Abrasion resistance:** The industry-standard Taber abrasion test indicated equivalent or better abrasion rates among the LTAVD samples. The samples with a CrN base layer yielded a 30 percent improvement in resistance compared with the electroplated chromium samples.
- **Base layer:** An added advantage of LTAVD is its ability to tailor the coating's base layer to produce material properties that can specifically align with an application's requirements for hardness, durability and corrosion resistance.





Experiment methodology*

*Contact Vapor Tech for further details as well as the test standards used to gauge performance.

MATERIALS:

10 x 10 cm carbon steel coupons

- 1/3 coated with conventional Cr^6 plating
- 2/3 coated in a VT 1500 LTAVD chamber

COATING STACK THICKNESS:

Approximately 25 microns

ANALYSIS RUN:

Elemental profiling via glow discharge spectroscopy

EVALUATED FOR:

- Corrosion
- Color
- Hardness and elasticity
- Abrasion resistance

Customers are currently evaluating thin films made with RAAMS (Vapor Tech's newest innovation available exclusively on the Cadence FLEX deposition system). When compared to PVD magnetron sputtering and cathodic arc techniques, RAAMS delivers greater durability and hardness, as well as a lower coefficient of friction. For details on performance attributes and comparative data using this deposition technique, contact Vapor Tech.

A promising future

The experiment's most significant takeaway is that the LTAVD coating offers equivalent – and often superior – functional characteristics compared to electroplated samples. The VT series of deposition systems with Vapor Tech's proprietary LTAVD process technology provides an alternative to electroplating 3D parts for decorative and functional chrome surface coatings. Additionally, LTAVD delivers a wide range of metallic colors, available coating materials, and coating material performance options not possible with a chrome plating line. The process is incredibly flexible in that it coats almost any substrate – including prepared plastic, plastic/polycarbonate blends, and low-melting-temperature metals such as zinc and brass – a key consideration for manufacturers that want to reduce material and processing costs by using cast-made parts. Manufacturers can choose lower-cost, easier-to-process base materials and still produce a finished product that is colorfast, hard, and corrosion- and abrasion-resistant, while minimizing the impact on the environment.

Vapor Tech®

About Vapor Tech

For more than 25 years, companies in a variety of industries have relied on Vapor Tech's industry-leading coating technologies to ensure their products feature premium surface finishes and functional coatings. Vapor Tech is a subsidiary of Masco Corporation.

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