A Basic Introduction to Thin-Film Coatings

From the Experts at VaporTech
What are thin-film coatings?
Thin-film coatings

Physical or Chemical Vapor Deposition (PVD or CVD)

PVD (physical vapor deposition) thin-film coating is a process in which a solid material, often a metal, is vaporized in a vacuum and deposited, atom-by-atom, onto the surface of a part. This material may be combined with nitrogen, oxygen, or a carbon containing gas to form compound materials.

The process forms a thin, bonded, metal or metal-ceramic layer on the surface that greatly improves the appearance, durability, and/or function of a part or product. The deposition process can be easily customized to change the color, durability, or other characteristics of a coating.

PE-CVD (plasma enhanced chemical vapor deposition) thin-film coating is a process in which the atoms in a gas are energized and deposited on a surface. DLC (diamond-like carbon) coatings are an example of a thin-film coating deposited using a PE-CVD process.
Application examples

- Biocompatible Materials
- Durable, Sharp Surgical Instruments
- Friction Bearing Surfaces
- Precision Seal Interfaces
- Gears & Bearings
- Drills, Mills, Cutters
- Industrial Tools
- Punches & Dies
- High-Performance Engine Parts
- Fuel System Components
- Aerospace Parts
- Electronics
- Sporting Goods
- Firearms
- Automotive Trim
- Home Products
- Jewelry & Watches
Some advantages of thin-film coatings

- **Extremely thin**: Typically 0.25 to 10 microns (0.01 to 0.4 thousandths of an inch), perfect for high-tolerance components where dimensions or mass are critical to functionality.

- **Durable**: Significantly more durable than hardened steel and extremely wear resistant.

- **Improved appearance**: Improve both durability and appearance with a broad range of colors from stainless steel to black.

- **Flexibility**: Coat hardened metal or even plastic parts without softening using VaporTech’s unique, low-temperature thin-film process.

- **Reduce Waste**: Minimize your environmental impact with a thin-film coating process that generates no hazardous waste.
How do thin-film coatings compare?

• Thin film compared to powder coating
  • Products last longer due to significantly increased hardness and resistance to wear.
  • Minimize part tolerance issues with a finish that is more than 50 times thinner.
  • Improve UV resistance with a metal-based finish vs an organic polymer.

• Thin film compared to electroplating
  • Improved scratch and wear resistance due to increased hardness.
  • Differentiate a product with a broad range of metallic colors.
  • An environmentally friendly process that does not require the use of acids, cyanides, or hexavalent chrome.
  • Thin films can also be deposited over an electroplated base-layer to improve wear resistance and offer a broad range of colors.
What thin-film colors are possible?

VaporTech’s thin-film deposition systems can apply durable coatings to a variety of part sizes and geometries in a vast array of colors.
How are parts processed?

1. Machined parts are cleaned to remove oils and particulates.
2. Parts are loaded onto carriers or “racks.”
3. Racks with parts are loaded into the vacuum chamber of a coating system.
4. The operator initiates an automated coating process.
5. Parts are unloaded and transferred to assembly or packaging.
The PVD thin-film process

1. The coating system chamber is pumped down to a high vacuum.
2. Parts are etched/cleaned by creating a high-energy argon plasma in the chamber.
3. Energy is added to a metal target causing it to vaporize through a “cathodic arc” or “sputtering” process.
4. A high-voltage is applied to the parts to help draw vaporized metal to the surface.
5. A thin layer is deposited to improve coating adhesion, followed by one or more primary coating layers.
6. Small amounts of nitrogen, oxygen, or carbon-containing gases are added, which combine with the vaporized metal to form new compound materials with unique colors or functional characteristics.
7. The coating system chamber is cooled and brought back to atmospheric pressure.
DLC is a carbon-based thin film that can provide extreme hardness, reduced friction, and a unique appearance. Typical DLC applications include tooling components, engine parts, razors, watches, firearms, and medical devices. VaporTech’s DLC is a plasma-enhanced chemical vapor deposition (PE-CVD) process.

1. The coating system chamber is pumped down to a high vacuum.
2. Parts are etched/cleaned by creating a high-energy argon plasma in the chamber.
3. A thin adhesion layer is deposited on the part surface to enhance adhesion of the DLC coating.
4. A carbon-containing gas is added to the chamber as a carbon source.
5. A high voltage is applied to the parts to create an argon plasma which will break the carbon bonds in the gas and deposit a diamond-like carbon finish on the part surfaces.
6. The coating system chamber is cooled and brought back to atmospheric pressure.
What does a coating look like?

The picture to the right is a cross-section of a functional chromium nitride coating, deposited by combining chromium metal with nitrogen gas, magnified 2,500 times under an electron microscope.

The bottom layer is the surface of the part, followed by a thin layer used to improve coating adhesion, and finally the coating itself (the new durable surface of the part). This is an example of an extremely durable coating, suitable for high-wear metal surfaces.
Glossary of terms

- **Adhesion Layer**: As part of the thin-film deposition process, often a thin layer of metal is deposited on the part to make the coating adhere more effectively to the surface. The coating equipment will automatically deposit the adhesion layer as part of the coating process.

- **Cathodic Arc**: A PVD deposition method where a high-current electrical arc is applied to the surface of a target, causing the material to vaporize, ionize, and be deposited on a part.

- **Coating System**: The equipment required to deposit thin-film coatings. Consists of a vacuum chamber, pumping system, racking system to hold parts, power supplies used for deposition, and a control system/user interface.

- **Diamond Like Carbon (DLC)**: A thin-film coating made primarily of carbon with a diamond-like structure, extremely hard surface, low coefficient of friction, and gray to black color. It can be deposited using PVD or PE-CVD processes.

- **Magnetron Sputtering**: A PVD deposition method where a plasma is created at the surface of a target material, causing ions to bombard the target surface and eject coating material towards the surface of a part.

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Glossary of terms

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• PE-CVD (plasma enhanced chemical vapor deposition): A thin-film process where elements in a gas (carbon, for example) are deposited on the surface of a part in a vacuum.

• PVD (physical vapor deposition): A thin-film process where a solid metal or other material is evaporated in a vacuum and deposited on the surface of a part.

• Reactive Deposition: A process where a small amount of gas is added to a vacuum deposition process. The gas combines with the vaporized target material to form a new compound coating. This process can change the hardness, color, or other physical characteristics of the coating. An example would be adding nitrogen gas to chromium deposition, creating a more wear-resistant chromium nitride coating.

• Target or Source: A term used to describe the solid coating material before deposition. Different coating systems use different shape targets. Some common target materials include zirconium, chromium, or titanium.

• Thin-film Coating: A general term for any functional or decorative finish applied with a vacuum deposition process.
Please contact us to learn more about how thin-film coatings can improve the durability and appearance of your products.

Vapor Technologies, Inc.
Longmont, Colorado, USA
www.vaportech.com
vtsales@vaportech.com
303-652-8500