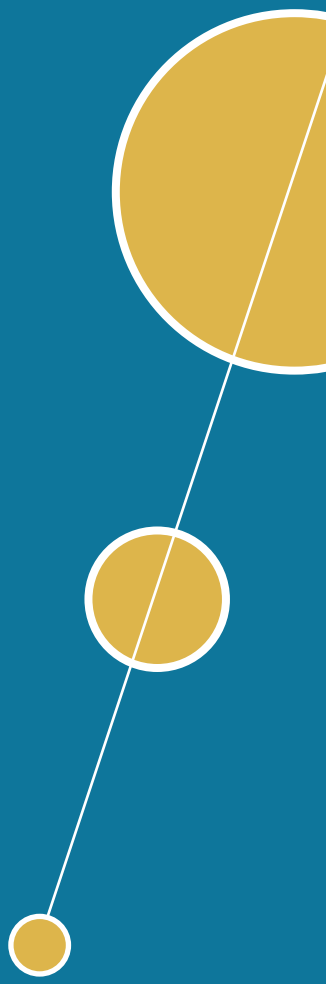
EDUCATIONAL GUIDE

A COMPLETE INTRODUCTION

Performance PVD Coatings



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Performance Coatings

Coatings for Tools, Tooling, Automotive, Medical Devices & More

Performance (also called functional or tribological) PVD coatings are designed to make your product last longer, resist corrosion, withstand high temperatures, and operate more efficiently due to lower friction.

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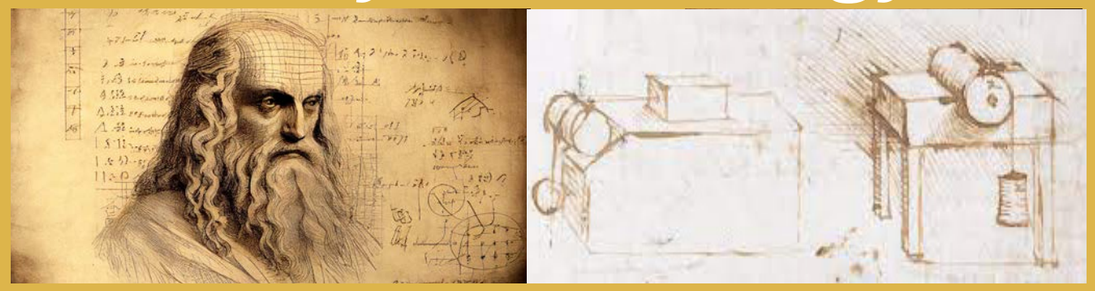
A History of Tribology



As documented in his sketchbooks, Leonardo da Vinci first discovered the two basic laws of friction in 1493.

According to scholars, humans started using steel about 4,000 years ago, thus forever altering how we live life, work, and fight wars. In ancient Greece and Rome, weapons-makers didn't take long to figure out that a very hard and sharp steel sword that lacks flexibility creates a fragile, breakable blade. They learned that, in many cases, having different properties on the surface provides the function they were looking for. Since then, humans have figured out how to better create items to be internally flexible but hard and sharp on the outside.

Jump forward to modern times. In the 1960s, a group of UK scholars began studying how to improve the efficiency of industrial manufacturing. The group figured out that the UK could save approximately £500 million a year by reducing friction and wear. Group member Professor Peter Jost, a mechanical engineer, spearheaded the effort to solve the wear and friction problem. Jost coined the term "tribology," meaning the science that would combine physics, chemistry, material engineering, and mechanical engineering to understand and solve these challenges.

Tribology has grown to the point that many companies, universities and research institutes have developed tribology labs. Established and well-known societies worldwide are now studying this field.

4,000 bc | Humans begin using steel.

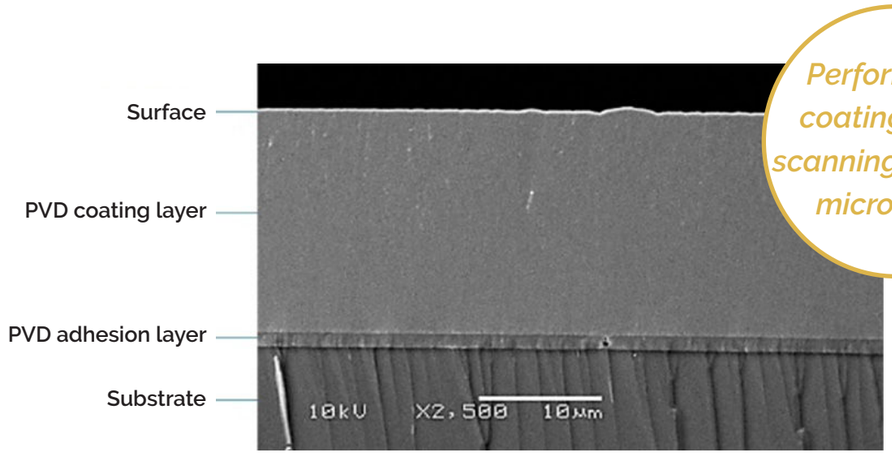
1493 | Da Vinci discovers two basic laws of friction.

1960s | Term "tribology" introduced.

2021 | Tribology is a major field of study.

Solve complex friction and wear problems

Performance thin-film coatings modify the hardness and toughness of the surface. They also improve durability, friction, and/or wear characteristics.



Performance coating under scanning electron microscope

The PVD process creates coatings that help manufacturers optimize their products' performance (and look). As the name suggests, PVD thin-film coatings are much thinner than other finishing technologies, which means the coating doesn't affect tight manufacturing tolerances.

Every time manufacturers around the world can't solve wear and/or friction problems efficiently, they turn to tribology. Using processes like lower-temperature cathodic arc deposition and magnetron sputtering, these companies create coating properties that match their specific applications. Tribology helps our customers change their parts and products' external/surface properties to maximize their desired qualities and minimize potential challenges. For example, the cutting tools used in machining sustain significant impact during operation, which is why manufacturers use extremely thin and friction-resistant PVD-coated metals. This way, the part has the characteristics it needs to function best with a coating that doesn't affect the product tolerance.

VaporTech Performance Coatings Properties & Applications

	CrN	TiN	TiCN	TiAlN	ZrN	ZrCN	ZrOC	a-C:H DLC	a-C:H:W DLC
NAME	Chromium Nitride	Titanium Nitride	Titanium Carbonitride	Titanium Aluminum Nitride	Zirconium Nitride	Zirconium Carbonitride	Zirconium Oxy-Carbide	Diamond-Like Carbon	W-DLC
COLOR	Metallic silver	Metallic gold	Gray	Brown to blue-black	Nickel to pale-gold brass	Bronze	Dark gray to black	Graphite to black	Various grays
	Excellent hardness/ toughness, reduced friction, resistant to sliding & impact wear, excellent resistance to corrosion & oxidation, good release properties.	Excellent hardness and toughness, biocompatible and non-toxic, reduced friction, compatible with acids/bases/ solvents.	High hardness, excellent abrasive wear resistance	High hardness and excellent wear resistance at high temperatures.	Excellent general purpose coating with high hardness/ toughness, good wear resistance, excellent corrosion resistance, biocompatible.	Excellent hardness, abrasion, and corrosion resistance.	Moderate hardness/ toughness and wear resistance, very good corrosion resistance.	An amorphous carbon coating with very low friction, high hardness, resistant to sliding wear, biocompatible, and an attractive appearance.	Tungsten doped hydrogenated amorphous carbon.
APPLICATIONS	Dies and molds, tooling for machining of Cu/Al, engine components, pump parts, and as a replacement for functional plated hard chrome.	Medical devices and surgical tools, food processing, cutting/ punching tools, rotating shank tools, machining of iron alloys, and molds/ dies.	Cutting/punching tools, dies for plastic injection molding, high pressure, low speed machining.	Cutting tools, drilling and milling of high-strength steels.	Cutting and punching tools, tooling for machining Al & Ti, medical devices and dental instruments.	Cutting/punching/ forming tools particularly for aluminum alloys and medical devices and instruments.	Tooling and durable consumer products that require good wear resistance with corrosion resistance and an attractive graphite or black appearance.	Automotive components, medical devices, dies, molds, firearms, cutting tools, sporting goods, and other durable consumer goods.	Bearings, engine and transmission components. Durable consumer goods.
COATING HARDNESS	14-25 GPa 1400-2500 HV	20-30 GPa 2000–3000 HV	28-38 GPa 2800-3800 HV	25-30 GPa 2500-3000 HV	25-27 GPa 2500-2700 HV	24-26 GPa 2400-2600 HV	17-21 GPa 1700-2100 HV	15–23 GPa 1500–2300 HV	8-15GPa 800 to 1500HV
THICKNESS RANGE	Typical 1–10 microns	Typical 1–5 microns	Typical 1–5 microns	Typical 1-4 microns	Typical 1–5 microns	Typical 1-4 microns	Typical 1–4 microns	Typical 1–4 microns	Typical 1–4 microns
COEFFICIENT OF FRICTION (CoF)	0.5-0.7 (dry; against alumina) 0.5 (dry; against steel)	0.5-0.6 (dry; against alumina) 0.4 - 0.6 (dry; against steel)	0.3 (dry; against alumina) 0.2 – 0.3 (dry; against steel)	0.6 (dry; against steel)	0.3 – 0.4 (dry; against alumina)	0.5 (dry; against steel)	0.3 – 0.4 (dry; against alumina)	0.08–0.11 (dry; against alumina) 0.1-0.2 (dry; against steel)	0.2 (dry; against steel)
MAX TEMP	700 C	600 C	400 C	750 C	600 C	600 C	600 C	300 C	300 C
		Yes	Yes		Yes	Yes		Yes	Yes

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Antimicrobial Coatings

Coatings that combine antimicrobial properties with chemical and wear resistance are applied to touch surfaces such as plumbing and hardware products used in public and private facilities.

Diamond-Like Carbon

What is diamond-like carbon (DLC)?

Diamond-like carbon (DLC) coatings blend the best qualities of graphite & diamond.

Although both graphite and diamond are made only of carbon, you can hardly find materials with more distinct properties. The reason behind those differences lies in their structure—the way carbon atoms interconnect. Graphite works nicely as a solid lubricant because the stiff paper-thin layers slide easily against one another. In contrast, the tightly packed, crystalline structure of diamond produces a form of carbon with both the highest hardness and thermal conductivity of any natural material.

Which processes are used for DLC coatings?

DLC coatings are deposited via plasma processes such as PE-CVD.

CVD can deposit a wide variety of materials from metals to plastics to ceramics to glass. The energy driving the reactions may come from heat (thermal CVD) or plasma-enhanced (PE-CVD). Thermal CVD is usually applied near atmospheric pressure, while plasma-enhanced CVD is often a vacuum process (we use PE-CVD in our VaporTech® coating systems).
A significant advantage of PE-CVD is that high temperatures are not required, enabling deposition on temperature-sensitive materials such as low-melting-point metals and alloys. A soft, elastic polymer coating will change into a hard, smooth DLC coating by simply varying the plasma energy during the PE-CVD process.

Does DLC create hard or lubricious coatings?

The answer is: BOTH!

The ability to tailor how the carbon atoms interconnect by changing process parameters allows us to produce materials approaching the hardness of natural diamond. However, there are trade offs. Harder coatings tend to be more highly stressed, which makes choosing the adhesion layer (the layer between the DLC coating and the surface) crucial, so the coating adheres well to the surface. In some applications, a softer but tougher coating will be more durable than a hard, stressed coating. In either case, lubricity helps lower the rate of wear.

Performance Coating Gallery

Add Value to Products

Incorporate the best tribological science to make great products even better by improving the function & durability of critical components.

To create the ideal coating solution for your specific application, you need to understand tribology and test these coatings . At VaporTech, our engineers, chemists, and physicists develop performance coatings in our dedicated lab. We've been helping customers like you apply PVD coating for more than 30 years.

Wonder whether our performance coatings & equipment will add function and value to your products? Please email or call VaporTech today!

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Let's find you the right finishing system!

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