

# 博世微波等离子体涂层系统

稳定高效涂层解决方案

# 博世等离子体技术 – 高产能涂层制造系统

## 核心技术

作为等离子体涂层的先驱之一,博世集团对这项前沿技术采取了整体规划方案。从1985年开始,中央研发部门不断开发DLC涂层和各类硬质涂层并成功应用于博世各领域的众多产品。与此同时,针对各类产品性能需求开发的特殊涂层,以及为满足高质量大规模量产的要求,博世智能制造解决方案事业部开始研发高性能等离子体源以及创新型等离子体技术。经过三十多年的经验累积及技术升级,博世等离子体技术成为了最具成本效益的涂层生产系统之一。

通过在9大博世涂层中心的生产经验累积,博世涂层技术专家在生产工艺链如何影响最终产品的质量和成本方面拥有丰富的经验。在工业互联的探索中,所有涂层设备均已配备相关的硬件和软件(支持IOT)。在生产过程中实现将自动化和物联网设备一体化是在涂层生产中获得竞争优势的重要成功因素。博世集团作为工业互联行业的领导者,拥有丰富的经验和资源,可以帮助您实现全自动生产管理。

## 质量是成功的关键

博世涂层秉持精益求精的德国工匠精神,质量根植于涂层技术的设计和应用理念。依据多年生产的要求和经验,不断的组件优化以延长配件寿命并简化维护,持续的软件升级以稳定工艺并简化操作,先进的控制系统以监测偏差并预估风险。

## 创新成就高效

博世等离子体涂层系统中独有的等离子体源在实现高速率镀膜的同时也可保证高品质。对于含氢类金刚石涂层(a-C:H)的化学气相沉积辅以微波技术,有效地将等离子体和偏压作用分离,从而提高了的沉积速率(约为传统PECVD技术效率的2倍),并且适用于大装载量。

对于无氢类金刚石涂层(ta:C),采用基于脉冲阴极电弧的专利技术。在保证类似含氢类金刚石涂层的沉积速率下,有效避免了传统离子源的劣势。

# 量身定制涂层系统配置

全系列涂层系统均采用模块化设计,并提供多种配件选择,以满足客户多样化的需求。基于系列配件的组合,博世涂层技术可覆盖全系列的碳基涂层。人性化且开放的操作系统,为您提供理想的自主开发平台。遍布全球的专家可以为您提供全方面的技术支持。

沉积源是获得目标涂层性能的关键。博世涂层系统提供了多种沉积源可供选择:

- ▶ 直流电弧源
- ▶ 脉冲电弧源
- ▶ HIPIMS
- ▶ 混合双阴极配置

诊断系统是确保生产质量并促进涂层领域发展的另一个重要组成部分。在此领域中,各类检测诊断系统已被集成于设备控制软件,客户可根据需求进行配置:

- ▶ 质谱仪
- ▶ OES系统(等离子体监测仪)
- ▶ 磁悬浮转子真空计系统

当然,所有的诊断系统都配备了现代化的接口并集成到控件中。

# PCS800

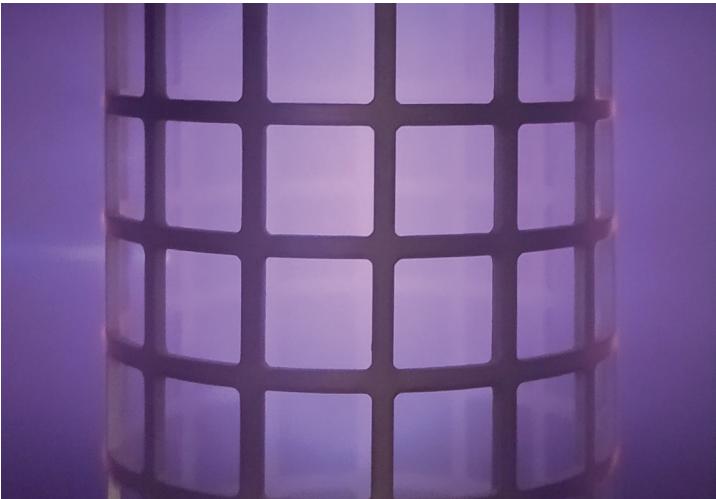
技术参数

涂层体系: DLC, Si-DLC, CrN  
可选配置: DC-ARC; 脉冲电弧阴极  
有效涂层范围: Ø 710x600mm  
涂层批次时间: 240 分钟  
最大载荷重量: 1000 kg



## 研发及批量灵活配置

结合不同的等离子体源,使PCS800成为多功能涂层机,用于高性能DLC涂层,ta-C或CrN等硬质涂层。它适合用作研发,也可用于小批量到中等批量的规模化生产。为了实现更高精度的过程监控,可搭载质谱仪或等离子体监测系统精密诊断设备。



# PCS1000

技术参数

涂层体系: DLC, Si-DLC, CrN  
可选配置: DC-ARC; 脉冲电弧阴极  
有效涂层范围: Ø 710x1000 mm  
涂层批次时间: 240 分钟  
最大载荷重量: 1000 kg



## 高效 质量 双重保障

PCS1000是博世在全球涂层中心广泛用于大规模批量生产的明星机型。不断的改进,使得涂层系统的稳定性和操作友好性得到最大的提升。关键优势之一是用于产生等离子体的微波技术可实现高沉积速率,这确保了高性能涂层的经济高效性。





# PCS OPTIMA

技术参数

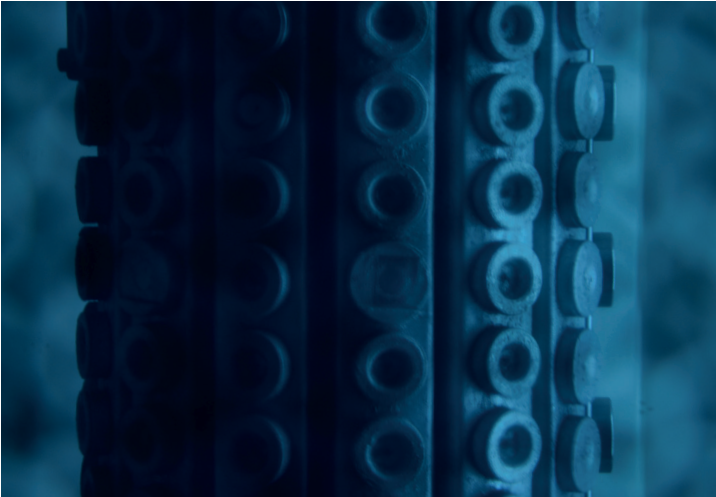
涂层体系: DLC, ta-C, Si-DLC, CrN  
可选配置: HiPIMS; DC-ARC;  
有效涂层范围: Ø710x1000mm  
涂层批次时间: 240 分钟  
最大载荷重量: 1000 kg



## 创新型涂层解决方案

PCS OPTIMA是用途最广泛的等离子体涂层系统,可以配备许多不同的创新型等离子体源。这是需要量身定制涂层解决方案客户的理想选择。

- ▶ 脉冲电弧源: 高效ta-C
- ▶ 微波源: 高效蚀刻和DLC涂层
- ▶ DC-ARC阴极
- ▶ HiPIMS阴极
- ▶ 等离子体诊断: 质谱仪, 等离子体监测仪等



# 类金刚石涂层 (DLC) 陶瓷涂层的比较

		类金刚石涂层 (DLC)				陶瓷涂层	
		C1	C2.1	C2.X	C3	CrN: Me	MoN: Me
材质		WC:C	a-C:H	a-C:H:x	ta-C	氮化铬	氮化钼
典型厚度[μm]		0.5-2	1-4	1-4	0.5-2	2-3	2-3
与钢的干摩擦系数		0.16	0.15	0.1	0.25	0.15	0.2
硬度[HV]		1500-2000	2000-3000	1000-2500	3000-6000	2500	2000-3000
最大耐受温度 [°C]		300	300	400	450	700	645
涂层工艺温度 [°C]		160-220	<200	<200	<200	<200	<200
耐磨性	磨粒磨损	++	++	++	+++	++	+
	腐蚀磨损	++	+++	++	++	++	+
	粘着磨损	+	+	+	+	+	+
	接触疲劳磨损	++	+	+	++	+++	+++
偶件磨损		++	+++	++	++	+	++
耐腐蚀磨损		++	++	++	++	++	+
抗颗粒物磨损		++	+	+	++	+++	+



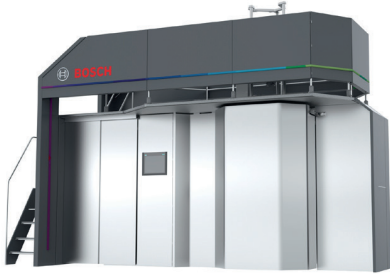
博世等离子技术 – 系统概览



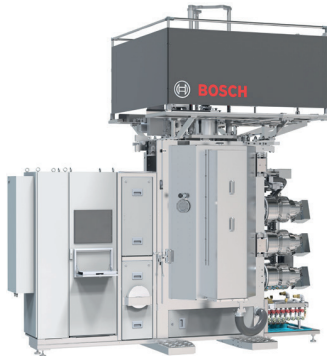
PCS DESKTOP



PCS800



PCS1000



PCS1500



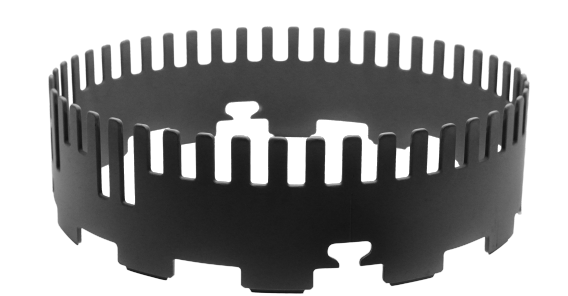
PCS OPTIMA

标准配置	PA-CVD (离子束)	溅射+PA-CVD (微波)	溅射+PA-CVD (微波)	溅射+PA-CVD (微波)	脉冲电弧阴极+溅射+PA-CVD (微波)
有效涂层范围	D 150 H 200	D 710 H 600	D 710 H 1000	D 710 H 1500	D 710 H 1000
最大载荷重量	3 kg	1000 kg	1000 kg	2000 kg	1000 kg
适用涂层体系	high rate DLC	DLC / Si-DLC / CrN	DLC / Si-DLC / CrN	DLC / Si-DLC / CrN	DLC / ta-C / Si-DLC / CrN
涂层工艺时间/批次	0.25 – 0.50 小时	4 小时	4小时	4 小时	4 小时/ ta-C 2 μm
可选配置	Si-DLC, Duplex	DC-ARC, 脉冲电弧阴极	DC-ARC, 脉冲电弧阴极	DC-ARC, 脉冲电弧阴极	HiPIMS, DC-ARC

# DLC涂层应用

## 模具

DLC涂层在成型模具中为模具表面提供了较高的硬度、低摩擦系数和优异的抗粘附性能。成型模具用于生产各种复杂形状的制品。DLC涂层还具有优异的耐腐蚀性，能够抵御化学腐蚀和氧化，确保模具表面的稳定性和耐用性。



## 零部件产品

DLC涂层在零部件制造中广泛应用，如轴承、气缸、活塞环等关键部位。涂层显著提高耐磨性和抗腐蚀性，显著提高零部件使用寿命，同时减少摩擦损耗，提高工作效率。在汽车、航空航天、工程机械等领域，DLC涂层成为关键技术，改进了零部件的性能和寿命。制造商采用DLC涂层技术，降低维护成本，提高设备可用性，为客户提供更高价值和满意度。



## 缝纫纺织部件

DLC涂层是纺织行业一种洁净解决方案。DLC具有良好的自润滑性，是实现缝纫机零部件无油化的有效手段，广泛应用于纺机行业设备，如无油针杆、无油旋梭、各类连杆轴、滑块等部件。



## 精密刀具

DLC涂层具有出色的抗粘附性能，可减少切削有色金属和易粘连材料导致的刀具表面粘附，可提高加工质量，确保切削过程稳定。通过DLC涂层，刀具的硬度和耐磨性显著提高，延长寿命，减少更换频率，提高生产效率。







### 涂层系统

从用于快速制样的台式设备到高产能涂层系统,我们提供用于博世全球涂层工厂使用的多尺寸多规格设备。



### 物联网-自动化与互联产业

量身定制的解决方案,用于工艺流程和检测环节。物联工业的创新概念可以实现智能的涂层工艺流程。



### 交钥匙解决方案

基于对博世对涂层产品生产的了解,我们为您提供车间布局设计或优化咨询。



### 服务

通过向遍布全球的博世涂层中心提供支持,我们建立了一支由设备,软件和工艺专家组成的全能团队,可为您提供个性化服务和支持。



### 工艺开发

在等离子体涂层方面具有长期经验的开发工程师和物理学家团队非常乐意承接定制开发项目或以我们的专业知识为您的专家团队提供更多元化的支持。



#### Robert Bosch Manufacturing Solutions GmbH

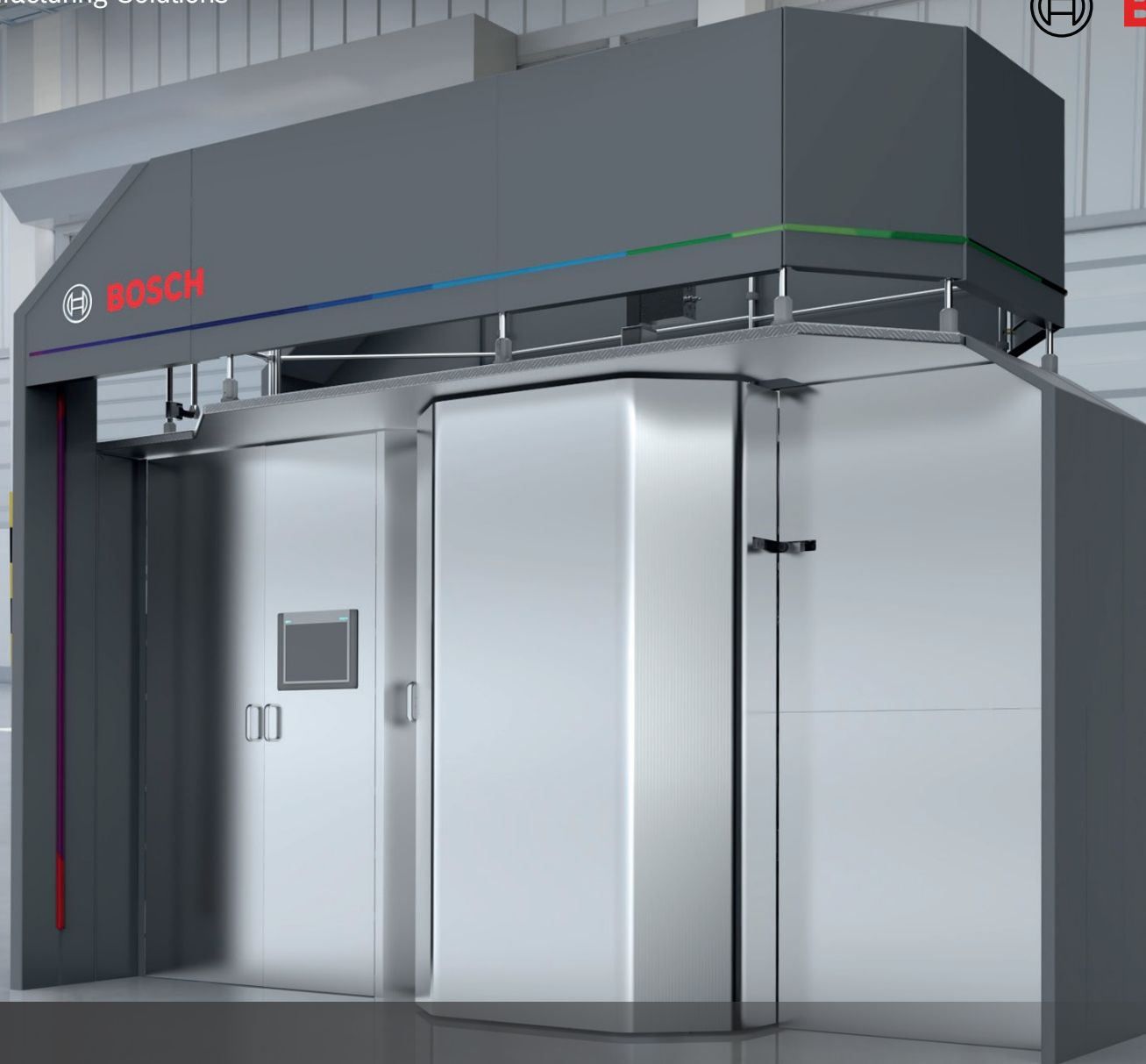
Wernerstr. 51  
70469 Stuttgart  
Deutschland  
+49 (711) 811-30600  
coating@de.bosch.com

[www.bosch-manufacturing-solutions.com](http://www.bosch-manufacturing-solutions.com)

#### 博世汽车部件(苏州)有限公司 博世智能制造解决方案 苏州

星龙街455号  
苏州工业园区  
江苏省 中国  
coating@cn.bosch.com





# BOSCH Microwave Plasma Coating System

Stable and High Efficiency Coating Solutions



# Bosch Plasma Technology – Coating machines for highest demands

## Benchmark in Technology

Robert Bosch is among the pioneers in Plasma based coating. Starting from 1985 Bosch is continuously developing DLC- and Hardcoatings for industrial use. The resulting coatings are nowadays successfully applied by Bosch in many of our products. Since the starting time Bosch uses a holistic approach on the topic. High quality combined with high productivity is ensured by a large number of inhouse developed Plasma sources targeted for the specific process. Additional to coating performance we also focus on reliable and efficient coating machine technology. As a result we ensure a cost effective production process.

By using this technology in our own coating centers we have a rich experience how the production chain affects quality and cost of the final product. The integration of automation and connected devices in the production process is an important success factor in coating production yielding a competitive advantage for your coating centre. All coating machines are already equipped with required hard and software (IOT ready). Being part of the Bosch group, a leader in connected industry, we have a rich experience and resources to implement fully automatic production management in your production.

## Quality – the key to success

For Bosch group quality is a key factor to success, and this is seen in the design of our coating machines. Based on the requirements from our own inhouse production all components have been optimized concerning service life and ease of maintenance. An advanced control system detects deviations, ensures quality and is easy to use.

## Technology based on Innovation

The proprietary plasma sources used in our coating machines allow for high rate coating and excellent coating quality. For a-C:H coatings we employ a microwave-based technology. This technology allows for effective decoupling of the plasma generation and the substrate bias. The resulting process provides very high coating rate (2x higher than competitors) and is largely insensitive to batch configuration.

For ta-C coatings we employ a dedicated source technology based on pulsed cathodic arc. This source allows coating rates similar to a-C:H coatings and therefore overcomes this frequent disadvantage of other sources available in the market.

# Coating machines made to measure

All our coating machines follow a modular design and are available with a variety of options to adapt the technology to your needs. Based on this portfolio you can deposit all well-established carbon based coating types. The platform is also a perfect base for your own developments. Our experts can support you in all technical matters.

Deposition sources are the key-component to obtain targeted coating properties. For this reason, we provide a wide variety of sources for our coating systems:

- ▶ DC arc sources
- ▶ Pulsed arc sources
- ▶ HiPIMS
- ▶ Dual Cathode setups

Diagnostic equipment is another essential part to ensure production quality and facilitate development in the field of coatings. Also in this field we offer a variety of options which are fully integrated in the machine control software:

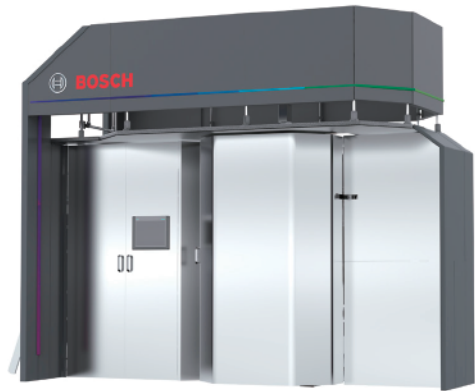
- ▶ Mass spectrometry
- ▶ OES systems (plasma monitor)
- ▶ Spinning rotor gauge

Of course, all measuring devices are equipped with modern interfaces and integrated into the monitoring.

# PCS800

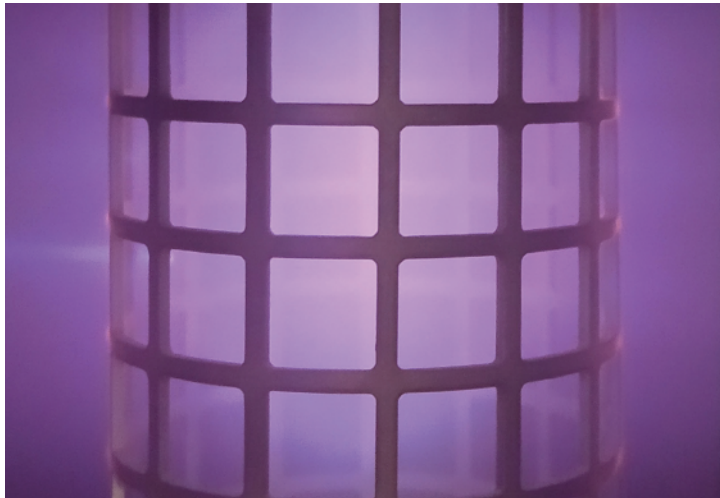
**Technical specification**

Coatings: DLC / Si-DLC / CrN  
Options: DC-ARC, pulsed cathodic arc  
Effective coating volume: Ø 710 x 600 mm  
Coating time: 240 min  
Maximum load mass: 1000 kg



## Flexible setup for development and production

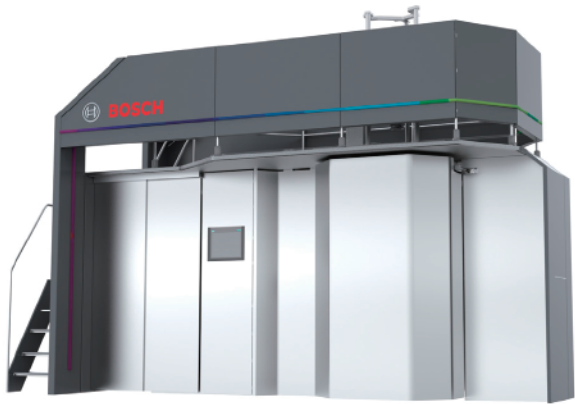
The possibility to combine different plasma sources makes the PCS800 a versatile coating machine that can be used to apply high performance DLC coatings, ta-C or hard coatings like CrN. It is suitable for development as well as small to medium series production. For advanced process monitoring the machine can be equipped with devices like mass spectrometer or plasma monitor.



# PCS1000

**Technical specification**

Coatings: DLC / Si-DLC / CrN  
Options: DC-ARC, pulsed cathodic arc  
Effective coating volume: Ø 710 x 1000 mm  
Coating time: 240 min  
Maximum load mass: 1000 kg



## Efficiency and Quality

PCS1000 coating machines are used in BOSCH coating centers world wide for large scale series production. Continuously improved they are highly robust and user friendly in operation. The microwave technology used for plasma generation allows a high coating rate which is one of the key advantages and guarantees cost efficient production of high performance coatings.





# PCS OPTIMA

**Technical specification**

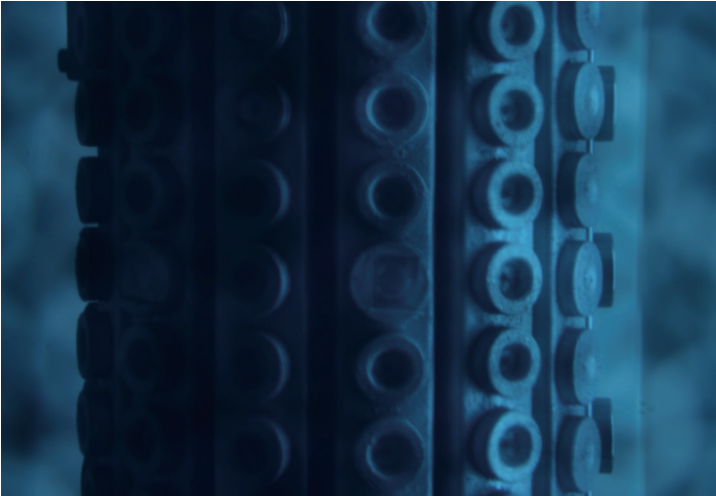
Coatings: DLC / ta-C / Si-DLC / CrN  
Options: HiPIMS; DC-ARC  
Effective coating volume: Ø 710 x 1000 mm  
Coating time: 240 min  
Maximum load mass: 1000 kg



## Innovation in coating

The PCS OPTIMA is the most versatile coating machine and can be equipped with many different innovative plasma sources. It is the perfect solution for applications that require a tailored coating solution.

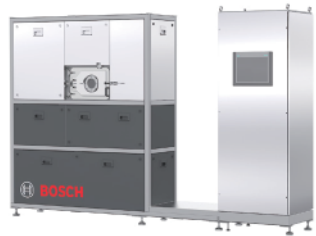
- ▶ Pulsed ARC source for high rate ta-C
- ▶ Microwave source for efficient etching and DLC coatings
- ▶ DC-ARC cathodes
- ▶ HiPIMS cathodes
- ▶ Plasma analytic : mass spectrometer or plasma monitor



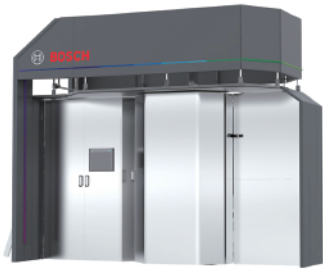
# Comparison of DLC layers with ceramic layers

		DLC				Ceramic	
		C1	C2.1	C2.X	C3	CrN: Me	MoN: Me
Material		WC:C	a-C:H	a-C:H:x	ta-C	CrN	MoN
Typical coating thickness [µm]		0.5-2	1-4	1-4	0.5-2	2-3	2-3
Coefficient of friction dry against steel		0.16	0.15	0.1	0.25	0.15	0.2
Hardness [HV]		1500-2000	2000-3000	1000-2500	3000-6000	2500	2000-3000
max. operating temperature [°C]		300	300	400	450	700	645
Coating temperature [°C]		160-220	<200	<200	<200	<200	<200
Wear resistance	Abrasion	++	++	++	+++	++	+
	Tribochemical reaction	++	+++	++	++	++	+
	Adhesion	+	+	+	+	+	+
	Surface disruption	++	+	+	++	+++	+++
Counter body wear		++	+++	++	++	+	++
Corrosion resistance		++	++	++	++	++	+
Particle wear resistance		++	+	+	++	+++	+

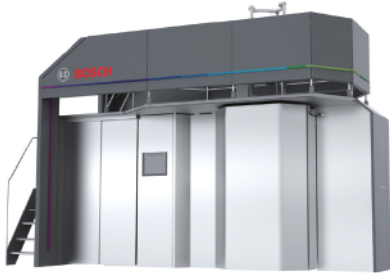
# Bosch Plasma Technology – Machine overview



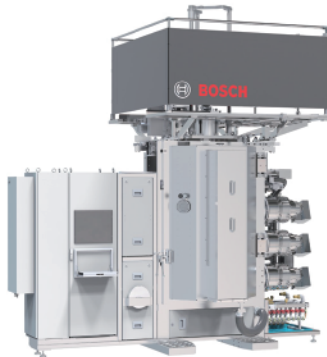
**PCS DESKTOP**



**PCS800**



**PCS1000**



**PCS1500**



**PCS OPTIMA**

Standard technologies	PA-CVD (Plasma jet)	Sputtering + PA-CVD (MW)	Sputtering + PA-CVD (MW)	Sputtering + PA-CVD (MW)	Pulsed cathodic arc + Sputtering + PA-CVD (MW)
Coating volume	D 150 H 200	D 710 H 600	D 710 H 1000	D 710 H 1500	D 710 H 1000
Max. load	3 kg	1000 kg	1000 kg	2000 kg	1000 kg
Standard coatings	high rate DLC	DLC / Si-DLC / CrN	DLC / Si-DLC / CrN	DLC / Si-DLC / CrN	DLC / ta-C / Si-DLC / CrN
Process duration / cyle time	0.25 – 0.50 hrs	4 hrs	4 hrs	4 hrs	4 hrs / ta-C 2 µm
Options	Si-DLC; Duplex	DC-ARC; Pulsed cathodic arc	DC-ARC; Pulsed cathodic arc	DC-ARC; Pulsed cathodic arc	HiPIMS; DC-ARC



# DLC Coating Application

## Molding

In molding application, DLC (Diamond-Like Carbon) coatings provide an extreme high hardness, low friction coefficient, and superior anti-adhesive properties. Molding dies are utilized for producing products of various intricate shapes. Additionally, DLC coatings provide exceptional corrosion resistance against chemical corrosion and oxidation, ensuring the mold surface's stability and durability.



## Parts products

DLC coatings are extensively used in parts manufacturing, notably in critical components such as bearings, cylinders, and piston rings. The coating significantly enhances wear resistance and corrosion protection, prolonging the lifespan of components, while reducing frictional losses and elevating operational efficiency. In sectors like automotive, aerospace, and construction machinery, DLC coatings have emerged as a pivotal technology, advancing the performance and lifespan of parts. Manufacturers choosing DLC coating technology benefit from reduced maintenance costs and enhanced equipment availability, delivering increased value and satisfaction to their customers.



## Sewing and Textile Components

DLC (Diamond-Like Carbon) is a clean solution for textile industry. With its excellent self-lubricating properties, DLC coating serves as an effective method for oil-free sewing machine components. It's widely adopted in textile machinery equipment, including oil-free needle bars, oil-free rotating shuttles, various connecting rod shafts, sliders, and other components.



## Precision Cutting Tools

DLC coating provides excellent anti-sticking properties, reducing tool surface adhesion caused by cutting non-ferrous metals and sticky materials. This enhances machining quality and ensures stability throughout the cutting process. With DLC coating, the hardness and wear resistance of the cutting tools are notably boosted, extending their lifespan, decreasing replacement frequency, and increasing production efficiency.





### Coating equipment

From a desktop system for fast sampling up to large batch coating systems we offer a wide spectrum of machines, which is also used worldwide in production plants of the Bosch group.



### IOT – automation and connected industry

Tailored solutions for handling and testing steps. Innovative concepts for connected industry allow a fully connected process flow.



### Turn Key Solutions

Based on know how from our own production we support the setup of your production location or provide consulting for optimization.



### Services

By providing support to our Bosch coating centers throughout the world we built a competent team of machine, software and process experts, our team is available to provide individual support for your needs.



### Process development

Our team of development engineers and physicists with long term experience in plasma coating is ready to take over targeted development projects or support your own experts with our know-how.



#### Robert Bosch Manufacturing Solutions GmbH

Wernerstr. 51  
70469 Stuttgart  
Deutschland  
+49 (711) 811-30600  
coating@de.bosch.com

[www.bosch-manufacturing-solutions.com](http://www.bosch-manufacturing-solutions.com)

#### Bosch Automotive Products (Suzhou) Co. Ltd

XingLong Str. 455  
SIP Suzhou  
China

[coating@cn.bosch.com](mailto:coating@cn.bosch.com)

