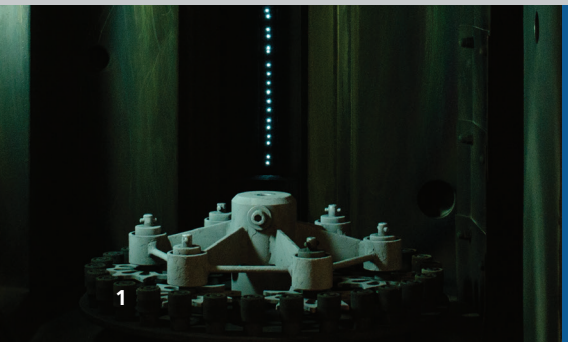
Fraunhofer
USA

FRAUNHOFER USA CENTER FOR COATINGS AND DIAMOND TECHNOLOGIES



1. **Laser-Arc® discharge**

2. **Optional plasma filter**

LASER-ARC® MODULE

Fraunhofer USA
Center for Coatings and
Diamond Technologies (CCD)

1449 Engineering Research Ct.
East Lansing, MI 48824, USA

Contact

Thomas Schuelke, Director
Phone: +1 517 4328709
ccd-info@fraunhofer.org

ccd.fraunhofer.org

IN COOPERATION WITH

MICHIGAN STATE
UNIVERSITY

Laser-Arc® Module & ta-C Coatings

The Laser-Arc® Module (LAM) is a modular plasma source for the large scale and high volume deposition of tetrahedral amorphous carbon (ta-C) thin film coatings in industrial physical vapor deposition machines. Such ta-C coatings are extremely hard and have a low coefficient of friction, which make them ideally suited for wear resistance applications. Ta-C is also biocampatible making it an excellent coating material for medical device applications.

The German engineered Laser-Arc® plasma source can be installed on production machines from various coating equipment suppliers. It is available in new machine installations and also as a retrofit solution for existing coating machines.

The Laser-Arc® Technology

The Laser-Arc® technology combines the advantages of pulsed laser deposition and vacuum arc deposition processes. The laser combined with an optical scanner defines the location of arc discharge for maximum graphite target utilization. The efficient pulsed arc process in combination with high repetition rates yields energetic plasma pulses and competitive deposition rates.

The process deposits highly sp3 bonded amorphous carbon films (ta-C) of extreme hardness and durability. The temperature impact on the substrate is minimized allowing for a deposition temperature well below 100°C. Typical film thicknesses range from nanometers to tens of micrometers, depending on the application requirements. The modular design of the Laser-Arc® technology allows for customized implementations.

1

2

Laser-Arc® Process

- Precise arc discharge control by pulsed laser for high energy density
- Oscillating laser in combination with cathode rotation for uniform target utilization
- High current pulse discharge: 1500 A
- Pulse duration: 0.13 – 0.33 ms
- Pulse frequency: 200 – 1000 Hz
- Deposition rate: up to 6 µm/hour
- Deposition conditions: gas-free, high vacuum ($p \leq 10^{-5}$ mbar)
- Deposition temperature: T < 100°C

Ta-C Coating Properties

- Hardness: 40 – 60 GPa
- Young's modulus: 400 - 600 GPa
- Coefficient of friction: 0.1 (dry); < 0.05 (lubricated)
- Thermal stability: 400°C (air); 650°C (vacuum)

Ta-C Applications

The high hardness and low friction of ta-C coatings in conjunction with biocompatibility and chemical resistance are particularly suitable for:

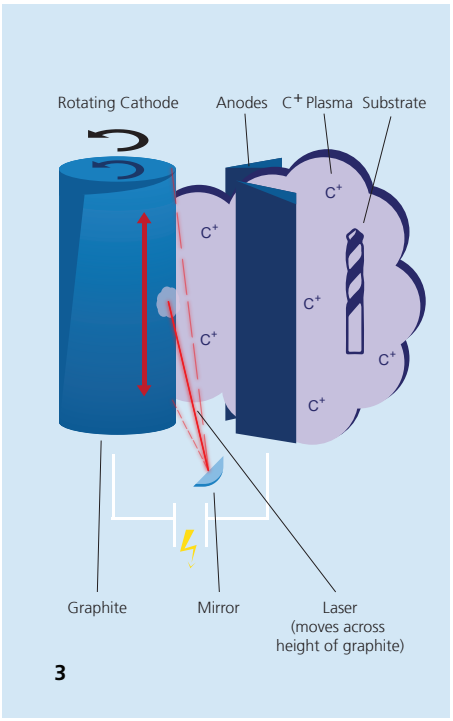
- Components and parts in automotive and mechanical engineering, e.g. piston pins and rings, pump components, etc.
- Cutting and forming tools
- Components for packaging, food processing and textile machinery that do not tolerate liquid lubrication
- Implants, components, devices for the pharmaceutical and biomedical industry
- Protective coatings for temperature sensitive materials (e.g. plastics and foils)

Laser-Arc® System Components

- Laser-Arc® Module plasma chamber with adapter to connect to coating machine flange
- Computer controlled system
- Pulsed high current arc power supply
- Optional: Pulse-synchronized power supply for substrate bias
- Optional: Plasma filter for particle minimization

Fraunhofer CCD Offer

Our engineering team offers retrofit solutions and complete coating machines with Laser-Arc® technology. Engineering services include system and coating demonstrations, application and coating process development, support during coating and equipment selection, installation and start-up. We offer all services necessary to successfully transfer the technology to our customers.



3

1. **Inside the Laser-Arc® Module**
2. **Industrial Laser-Arc® Module**
3. **Laser-Arc® Module coating process**