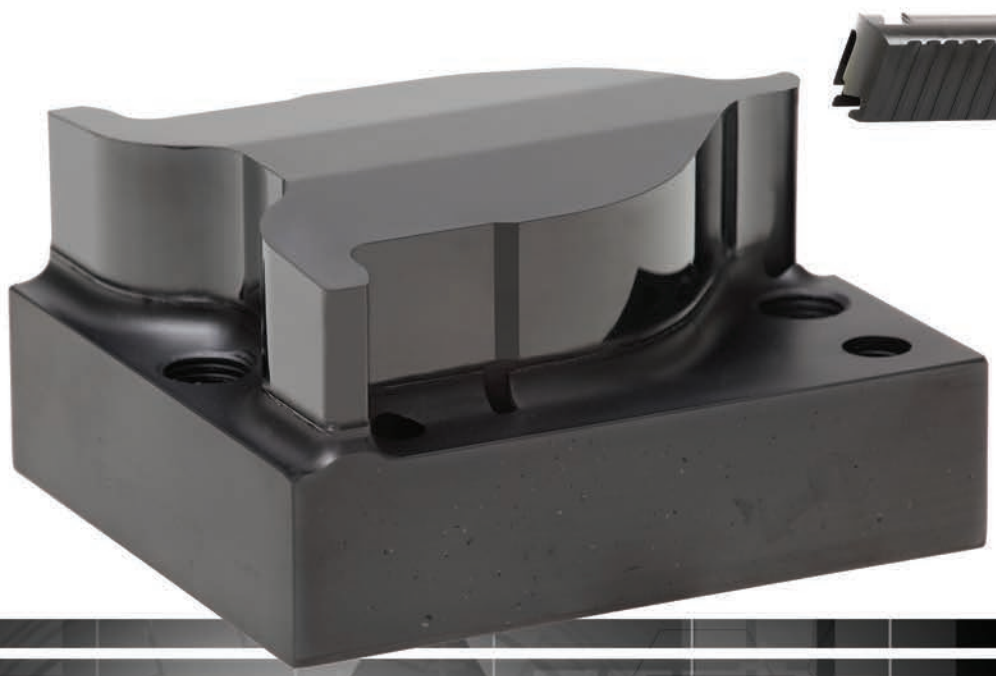


DLC

DIAMOND-LIKE CARBON

Our Family of Advanced
Carbon-Based PVD Coating Technology

RICHTER PRECISION INC.

RICHTER PRECISION INC.

Ahead of our time, and the competition

Richter Precision Inc. is North America's preeminent PVD, CVD, TD and DCD coating company. Since 1978, our coatings have been helping customers realize the full potential of their tools, thereby improving the efficiency and profitability of their manufacturing operations.

Our primary goal is to provide our customers with the best possible coating process and composition for their particular application. Diamond-like-carbon (DLC) coatings are an important factor in achieving this goal.

High Power Impulse Magnetron Sputtering

Richter Precision Inc. is the first commercial coating facility in North America to implement full industrial scale High Power Impulse Magnetron Sputtering (HIPIMS) technology. This technique can be used to apply very high power density pulses (>1000Wcm^{-2}) at selectable pulse duration 50-200μs and frequency 50-500Hz) to a magnetron cathode to produce exceptionally high plasma densities of the order of 10^{19}m^{-3} or greater.

Traditionally, the largest inherent problem with DLC coatings has been issues of adhesion: typically the higher the sp^3 percentage in a DLC film, the harder the DLC film but the higher the compressive stress within that film. In extreme cases, such stresses can create unstable interfaces (i.e adhesion and/or cohesion issues) and the film may become prone to delamination. HIPIMS technology can be used to alleviate this problem by priming the substrate surface prior to coating through shallow metal ion implantation and increased interface strength.

HIPIMS sources generate an unusually high metal ion concentration in the sputter plasma (>80% ion fraction unlike traditional sputter sources which are typically <5%). Ions arriving at the substrate may be accelerated by applying a biasing voltage on the substrates (typically 600-1200 V) which substantially increases ion energy and sputtering efficiency on the substrate surface. If the energy is high enough, shallow metal ion implantation to create a sub-surface inter-metallic layer may take place, controlling surface stresses and modifying surface lattice parameters to improve the adhesion. Furthermore, this technology produces extremely smooth films and does not create excessive radiant heating or macro-particle incorporation. This leads to dense films that are free from macro-growth defects.

Our Titankote™ C12 (Me-DLC) and Titankote™ C14 (C-DLC) both employ this exciting new technology. Please contact us to find out how this technology can improve a pending or existing DLC coating program.

Diamond-Like Carbon (DLC) Coatings

Diamond-like-carbon (DLC) coatings are a particular area of expertise for Richter Precision Inc. Among PVD & PaCVD coating compositions and technology, DLC coatings stand out as a particularly distinctive category. These coatings exhibit a desirable combination of a low coefficient of friction and high micro-hardness, making them extremely effective in many tribological and wear applications.

DLC coatings are formed when ionized and decomposed carbon or hydrocarbon species land on the surface of a substrate with energy typically 10-300eV. DLC films may possess exceptional mechanical (high hardness), optical (high optical band gap), electrical (high electrical resistivity), chemical (inert) and tribological (low friction and wear coefficient) properties and can be deposited at low substrate temperature (<200°C).

DLC films are generally amorphous (i.e have no dominant crystalline lattice structure) and consist of a mixture of sp^2 (graphite) & sp^3 (diamond) phases. Control of film properties is strongly dependent on the flux characteristics of the chosen deposition technique (PVD sputter or evaporation and Pa-CVD), metal and hydrogen content within the film, sp^2:sp^3 ratio, substrate bias voltage, ion energy and ion density as well as substrate temperature. DLC film friction coefficient against steel generally ranges from 0.05-0.20, whilst film hardness and sp^3 content can be tailored for specific applications. Metal and hydrogen containing DLC (Me-DLC or a-C:H:Me) exhibit hardness in the range 500-2000HV with 35% sp^3, metal free DLC (C-DLC or a-C:H) typically 1500-4000HV and up to 75% sp^3 , whilst tetrahedral amorphous carbon (ta-C) can be 4000-9000HV with 80-85% sp^3.

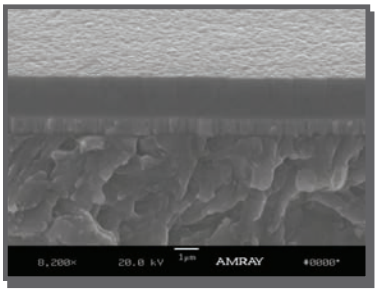
Richter Precision Inc. offers a complete range of DLC phase compositions, and hence the widest possible range of selectable mechanical and physical properties. The characteristics of the tools and/or application will determine which DLC coating structure would be best suited. A Richter Precision Inc. Coating Specialist would be pleased to aid you in your selection.

Please see the table below for a complete listing of our available DLC coating compositions.

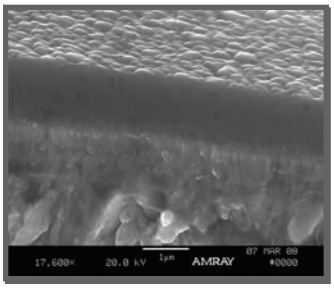
DLC Coating Specifications and Technical Data

Name	Composition	Thickness	Micro-hardness (HV)	Coefficient of Friction	Max. Working Temp.	Process Temp.
Titankote™ C10	DLC (ta-C)	0.5-2.5 μm	5000-9000	0.1	400°C/752°F	220°C/448°F
Titankote™ C11	DLC (a-C:H)	1.0-4.0 μm	2000-3000	0.1	350°C/662°F	220°C/448°F
Titankote™ C12	Me-DLC	1.0-5.0 μm	1000-2000	0.1	350°C/662°F	160°C/320°F
Titankote™ C14	C-DLC	1.0-3.0 μm	2200-4000	0.06 – 0.15	350°C/662°F	180°C/356°F

Data generated from lab samples. Characteristics may vary depending customer's material, surface condition and part geometry. Additional coating compositions, thicknesses, and processing temperatures are available upon request.



SEM image of Me-DLC



SEM image of C-DLC

Typical Applications for DLC Coatings

DLC coatings have many potential applications for tribological and wear applications. Typical areas of utilization for these coatings include:

Cutting *

- Drills
- End Mills
- Razor Blades
- Carbide Inserts

Metal Forming *

- Trim Steels
- Dies
- Fine Blanking Tools
- Punches

** - typically utilized for non-ferrous applications*

Molding

- Plastic Injection Molds:
  - Cavities & Cores
  - Ejector Pins
- Rubber Molds

Engines

- Valves
- Wrist Pins
- Tappets
- Pistons

Components

- Shafts
- Gears
- Bearings
- Cams or Slides

Locations

RICHTER PRECISION INC.
1021 Commercial Ave., Box 159
East Petersburg, PA 17520
Phone: (717) 560-9990
Fax: (717) 560-8741
E-Mail: info@richterprecision.com

RICHTER PRECISION INC.
34270 Riviera Drive
Fraser, MI 48026
Phone: (586)-465-0500
E-Mail: info@richterprecision.com

RICHTER PRECISION INC.
17741 Malyn Blvd.
Fraser, MI 48026
Phone: (586) 465-0500
E-Mail: info@richterprecision.com

RICHTER PRECISION INC.
9215 Brookfield Court
Florence, KY 41042
Phone: (859) 282-7777
E-Mail: info@richterprecision.com

WWW.RICHTERPRECISION.COM
Call 1-800-RICHTER
with any coating questions