SilcoTek® 101

A comprehensive overview of SilcoTek ® Corporation and its patented CVD coating process.

- History, vision and core values
- Coating solutions, applications and benefits
- Process overview
- More

Introduction

SilcoTek® is a coating service company focused on applying its variety of proprietary chemical vapor deposition (CVD) coating solutions to customer-supplied parts. While SilcoTek doesn't actually sell any products, companies worldwide send anything from small tubes and fittings to custom reactors, sampling equipment and rocket components to the coating facility in Bellefonte, Pennsylvania for treatment.

Invented in 1987 as a solution for making metal chromatography columns chemically inert, Silcosteel® (now known as SilcoNert® 1000) became a hit with customers who embraced the technology and adopted the coating into the complete chromatography sample pathway. Over the years, new product developments based off of the original amorphous silicon (Si) layer such as SilcoNert® 2000, Dursan®, Silcolloy® and SilcoKlean® have made their way into the refining, petrochemical, semiconductor, aerospace and biomedical manufacturing industries, to name a few. From durable corrosion resistance to ultra-high purity protection, SilcoTek's coatings are critical in processes everywhere.

This guide will summarize the history of SilcoTek's coating solutions, how customer-supplied parts are processed, and the applications for which the coatings offer benefits. Please contact the SilcoTek team at SilcoD@SilcoTek.com or 814-353-1778 for technical support, sales, or any other questions you may have.

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SilcoTek®
Driving Innovation

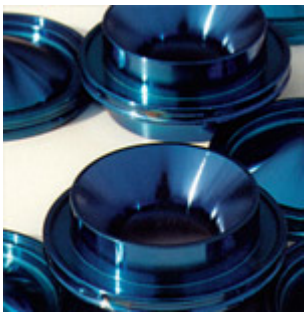
History and Development

1985

Paul Silvis opened Restek® for business in one room of an elementary-school-turned-business incubator.

1987

Restek® invents Silcosteel® coating and successfully applies it to instruments for the analytical industry.



1993

Restek® develops an approach for treating both the outside and inside of mass spectrometer components.

1998

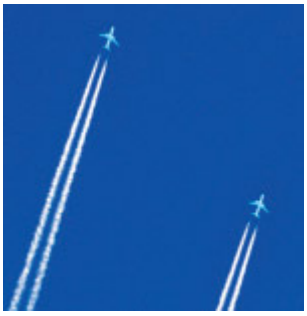
Restek® is awarded the first of several patents for surface treatments.

1999

Silcosteel®- treated air monitoring system components installed in the space shuttle Discovery.

2002

Restek® Performance Coatings develops into its own division of Restek®, expanding into a state-of-the art treatment facility.

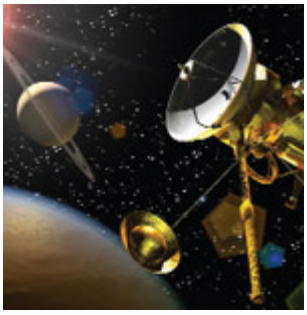


2003

Silcosteel®-AC (SilcoKlean®) and Silcosteel®-CR (Silcolloy®) developed.

2004

R&D magazine recognizes Silcosteel®-UHV (SilcoGuard®) as one of the 100 most technologically significant products of the year.



2004

Silcosteel®-treated components enter orbit on the Cassini-Huygens Mission to Saturn.

2006

Silcosteel® high-performance automotive coatings awarded 2 “Best New Product” awards at SEMA 2006.

2009

SilcoTek® is formed. The world's largest provider of silicon CVD treatment services.

2013

SilcoTek® completes construction of a new ultra-modern coating facility. More than tripling coating capacity.

Mission: Innovate coating solutions that boost material performance.

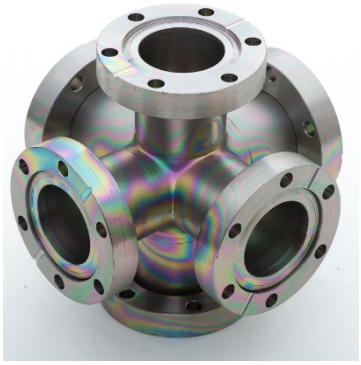
Vision: • 100 patents by 2020 • 100 off-site oven installations by 2020 • $100 million in revenue by 2020

SilcoTek’s ZIP Code: Zero Disappointments, Integrity in all we do, Plus 1 Service

The SilcoTek Difference

•*Better Coatings*

SilcoTek's chemical vapor deposition (CVD) is unlike other coating technologies because we use a proprietary blend of gas that chemically reacts and grows **into** (not just onto) the substrate. This means that even the smallest orifices or tricky openings will be coated, leaving customers confident in the performance of their Silco'd parts. Our R&D and Sales/Marketing teams work closely on a job-by-job basis to ensure that SilcoTek's coatings are the most effective solution to the challenges you face.



The material properties of our coatings are unique, too. We coat your parts at temperatures as high as 450° celsius which means they stay strong in hot environments where other coatings fail. Our thickest coating bonds at less than 2 microns, so even the tightest tolerances aren't affected. Since the treatment bonds into the substrate, SilcoTek's coatings can be bent, flexed and shaped to fit complex engineering geometries.

•*Better Process*

You likely haven't experienced a buying process like SilcoTek's. As soon as you request a quote online or by emailing SilcoD@SilcoTek.com, one of our technical sales representatives is evaluating your information along with any drawings and details you provided about the parts. While we guarantee a response within 1 business day, don't be surprised if you get your quote within 1 hour.

Our ISO 9001:2008-certified process begins with SilcoTek technicians photographing all received parts and verifying their quantities to your quote and/or purchase order. If

there are any discrepancies, part damage, or other red flags, our Customer Advocate will contact you. Once the parts enter the process, they are cleaned in ultra-high purity aqueous baths, inspected, and loaded into SilcoTek's CVD processing chambers. A rigorous visual inspection follows post-coat cleaning, and once approved by a Quality Technician, your parts are packed, shipped, and ready to perform at a higher standard than you've ever seen before.

•*Better Service*

SilcoTek's core values and vision revolve around how we treat each other and our customers. Our ZIP Code drives the beliefs that we live every single day:

- Zero disappointments
- Integrity in all we do
- Plus 1 customer service

Our entire process – from answering your preliminary questions to shipping your Silco'd parts back – involves a partnership where our experts talk to you, ask questions, and learn what we need to do to meet your needs without any disappointments. You will see SilcoTek's core values (FISHING) at work when you partner with us:

- **F**ast failure – not slow and stupid
- **I**n the light – we believe in integrity and don't hide anything
- **S**ervant leadership – management helps everyone succeed
- **H**onesty – the root of our success
- **I**nnovation – how we grow
- **N**ever stop learning – every employee is always improving and getting smarter
- **G**ive it all you got – the essence of who we are and why we're here

SilcoTek. Driving Innovation — The Silco'd Process

① RFQ OR

Visit www.SilcoTek.com, email SilcoD@SilcoTek.com or call 814-353-1778 to request a quote.

②

The team reviews your RFQ and part drawings. We contact you with any questions.

You get a quote, RA# and instructions for shipping parts to be coated.

Ship your parts to SilcoTek.

③

Once received, we inspect & photograph your parts for verifcation & traceability. We'll send you an order acknowledgement email.

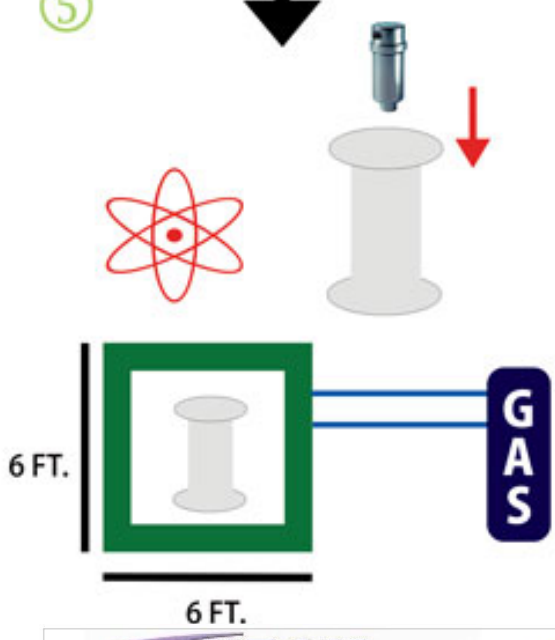
We're now on the clock. Expect your finished parts in 10-15 business days or less (depending on the coating).

④

A surface preparation step removes any contamination that will hinder the coating, even fingerprints.

They're then re-inspected before vessel loading to ensure quality.

⑤



Your parts are loaded into a vessel which is then placed into a CVD oven.

Over many hours, gas penetrates the entire oven and vessel.

Eventually, the gas forms a layer that bonds into and grows onto the substrate.

Your parts are now coated and able to perform better.

⑥

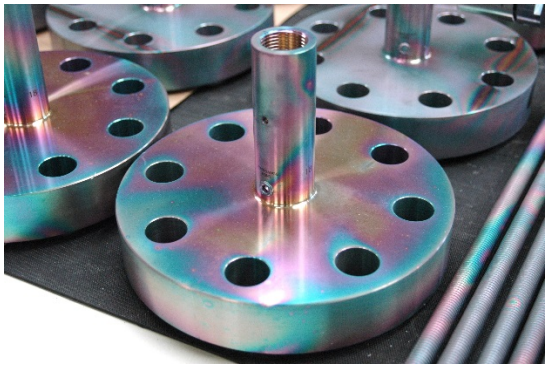
Following a rigorous quality inspection, SilcoTek's technicians photograph the finished parts and carefully package them to ensure they will be safe in transit.

We send you a notification email and your parts are shipped back ready to make what was impossible possible!

Silco'd Solutions

SilcoNert 2000

Also widely known as Sulfinert®, SilcoNert® 2000 is the ultimate surface treatment for chemical inertness and compatibility. This coating is required on metal and glass components when analyzing trace levels (as low as parts-per-trillion) of compounds, especially sulfurs (e.g. H_2S), mercury and ammonia. SilcoNert® 2000 is a functionalized layer of amorphous silicon (Si).

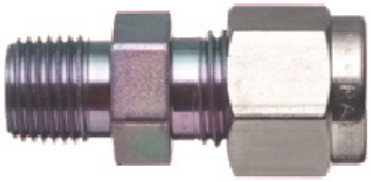


Dursan

Dursan® is our most versatile coating with key properties like hydrophobicity, durability and corrosion resistance along with the inertness and purity that SilcoNert® offers. Developed to withstand the rigors of down-hole oil and gas sampling, Dursan® prevents adsorption while acting as a physically tough layer against corrosion and abrasion commonly found in a variety of applications. Dursan's ceramic-like surface is amorphous silicon, oxygen and carbon, so it is suitable for the full pH range.

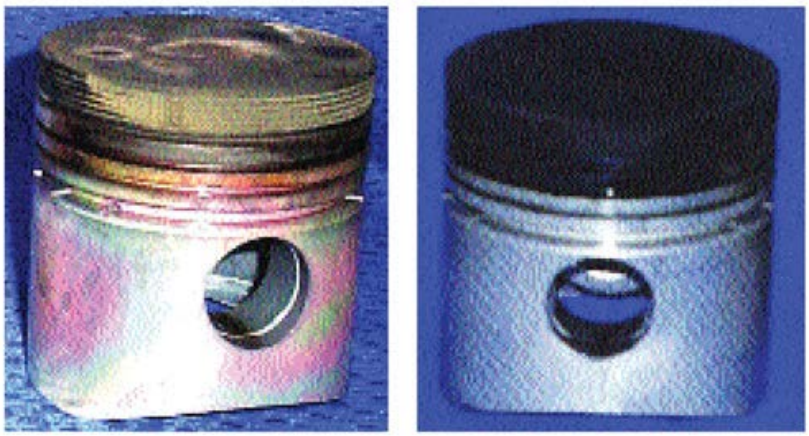
Silcolloy

Ideal for extending the life of systems and components in acidic and corrosive environments, Silcolloy® is a cost-effective alternative to expensive exotic materials and super alloys. Just like all of our current coating solutions, Silcolloy® begins as a layer of amorphous silicon which is then repeated for improved corrosion resistance.



SilcoKlean

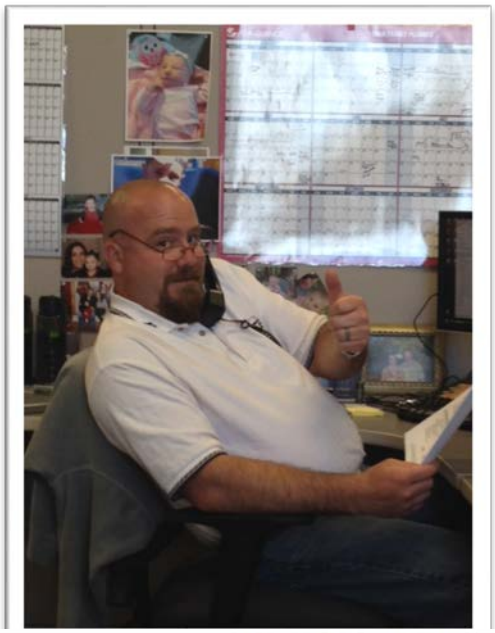
SilcoKlean® was developed in 2003 as a solution for carbon fouling a.k.a. coking in combustion-related components. Carbon buildup on these parts leads to engine failures, shorter maintenance cycles, and unplanned repairs. SilcoKlean® can be infused onto existing equipment as a protective layer from coking and will withstand extreme (1000° C+) temperatures. This surface treatment is a specially functionalized version of the original amorphous silicon layer.



SilcoGuard®

SilcoGuard® is designed to minimize outgassing in ultra-high vacuum (UHV) systems where rapid and efficient evacuations are crucial. This coating maintains a vacuum environment with little to no pre-cleaning or bake-out. SilcoGuard® is a multi-layered barrier of amorphous silicon.

SilcoTek's variety of coating solutions were developed to address the needs of both existing customers and new markets alike. There may be more than one Silco'd solution for your problem and, often times, choosing the right one is difficult. Our support team consists of the people who can answer your questions, make recommendations, and develop the surface you need. Whether you need a PhD materials scientist to understand more about how our coatings affect your system or a technical sales rep to visit your facility and make recommendations, we have the people here to help you overcome whatever challenge you face.



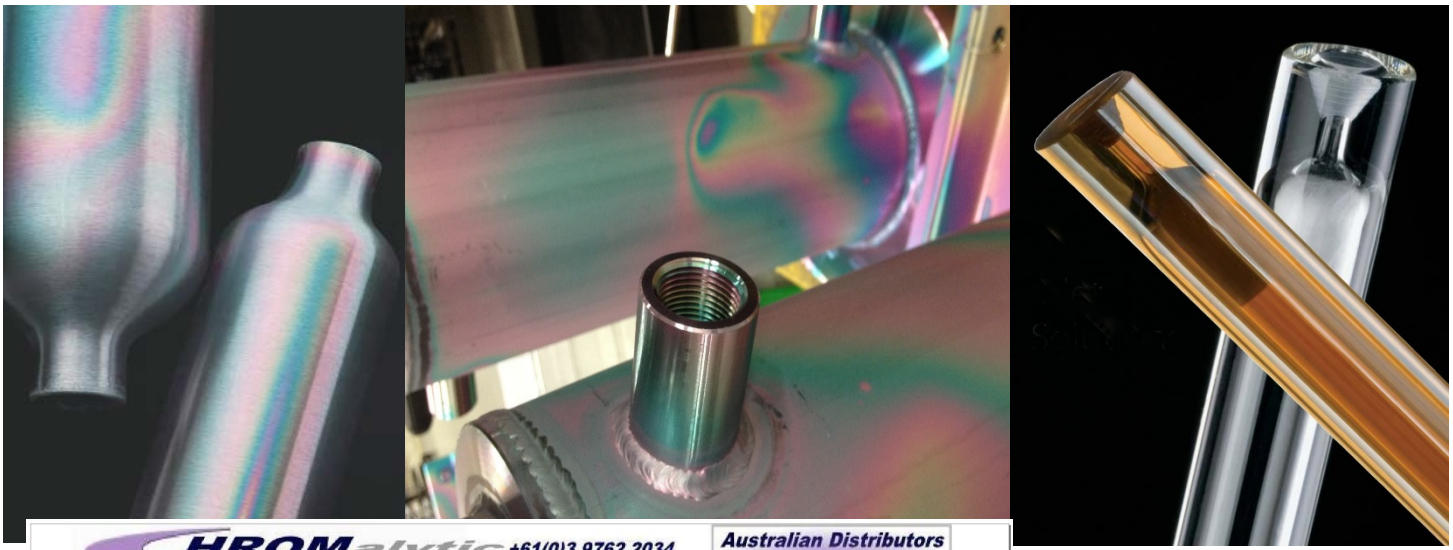
Applications, Industries and Benefits

SilcoTek's coating solutions are found in a diverse variety of applications and industry segments across the world. Since 1987, customers have relied on SilcoTek® to improve the performance of their products, exceed their capabilities and increase revenue.

We serve a long and unique list of industries, but they all have one thing in common: a need to improve how their equipment performs. SilcoTek's solutions expand the material limitations of your products and processes.

Current Industries Served:

- Aerospace
- Semiconductor
- Oil and gas exploration/production
- Refining and petrochemical
- Alternative energy
- Analytical instrumentation
- Bio/pharmaceutical
- Power generation



Aerospace

SilcoTek® customers:

Engine manufacturers, engine service firms, airline maintenance firms, NASA, instrument manufacturers, propulsion/engine manufacturers.

SilcoKlean® 1000 Features

- Anti-coking, Non-stick, non-reactive coating
- Durable & high temperature capable

SilcoKlean® 1000 Benefits

- Extend jet engine maintenance intervals
- Improved durability over ceramics

Silcolloy® 1000 Features

- Corrosion resistant silicon treatment

Silcolloy® 1000 Benefits

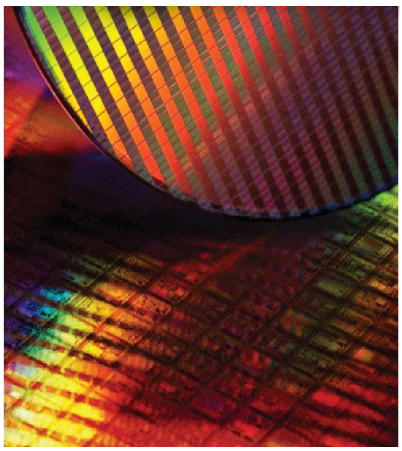
- Improved engine corrosion resistance

Dursan® Features

- Wear resistant, high lubricity surface
- Superior corrosion resistance

Dursan® Benefits

- Improved rolling and wear resistance
- Improved component durability



Semiconductor

SilcoTek® customers:

Gas system equipment manufacturers, FAB design firms, process/environmental monitoring departments, FAB equipment manufacturers, ultra high purity component manufacturers, wafer process/ handling equipment manufacturers, doping processes, lithography applications, valve and fitting manufacturers.

Silcolloy® 1000 Features

- High purity silicon deposition
- Moisture repelling
- Improved corrosion resistance
- Reduced contamination

Silcolloy® 1000 Benefits

- Reduced metal ion contamination
- Reduced moisture contamination
- Reduced maintenance cost
- Improved process yields

SilcoNert® 1000 Features

- Decreased equipment burn-in

SilcoNert® 1000 Benefits

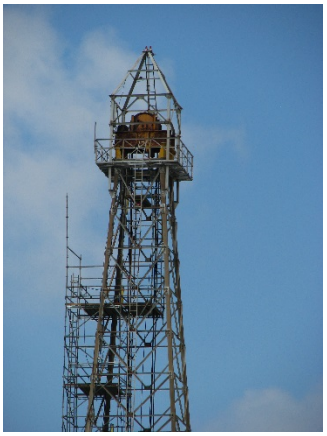
- Improved productivity

SilcoGuard® 1000 Features

- Rapid chamber pump-down

SilcoGuard® 1000 Benefits

- Reduced cycle times/higher throughput



Oil & Gas Production/Exploration

SilcoTek® customers:

Natural gas research consortiums, research facilities, oil services firms, engineering firms, field/well testing services, oil and gas exploration companies.

SilcoNert® 2000 Features

- Inert sample pathways
- Proven to low part-per-billion sensitivity
- High repeatability
- High sample stability over time
- Allows accurate grading of feedstock
- Low level mercury sensitivity
- Precise mercury sampling

SilcoNert® 2000 Benefits

- Eliminate false negatives
- Identify wells <50PPM Sulfur
- Faster/lower cost sampling
- Allows for remote/delayed testing
- Saves significant $ in processing costs
- Eliminate pump damage
- Allows accurate grading of feedstock
- Precise mercury sampling
- Allows mercury monitoring in the field

Dursan® Features

- Corrosion prevention
- Chemical inertness
- High temperature
- Wear resistant

Dursan® Benefits

- Reduces maintenance costs
- Reduce material cost, avoid using superalloys
- Prolong component life, reduce maintenance

Refining & Petrochemical

SilcoTek® customers:

Refineries, chemical plants, petro chemical plants, research laboratories, quality control labs, engineering and service firms, environmental and process monitoring departments.

SilcoNert® 2000 Features

- Precise low level sulfur sensitivity
- Part-per-billion sensitivity
- Improves instrument sulfur sensitivity
- Coated containers keeps sample stable for weeks
- Reduced water retention
- Reduces water in sampling systems

SilcoNert® 2000 Benefits

- Quantify feedstock sulfur levels
- Helps to prevent catalyst loss/poisoning
- Prevent instrument/process upsets
- Allows for remote or delayed testing of product without loss
- Reduces catalyst moisture contamination
- Reduced plant downtime and upset

Dursan® Features

- Improves corrosion resistance in full (0-14) pH range
- Tough and durable

Dursan® Benefits

- Reduced maintenance/downtime costs
- Reduced material costs, avoid use of superalloys

Alternative Energy

SilcoTek® customers:

University/research, fuel cell manufacturers, natural gas suppliers/fuel cell, coal gasification plants.

SilcoNert® 2000 Features

- Low level sulfur detection
- Inert silicon treatment

SilcoNert® 2000 Benefits

- Prevents catalyst damage
- Enables precise pollutant testing (NOx, SOx)

Silcolloy® 1000 Features

- Improved corrosion resistance
- High temperature capable
- May reduce hydrogen permeation & embrittlement
- Moisture resistant

Silcolloy® 1000 Benefits

- Reduced maintenance cost
- Reduced oxidation, reduced cost
- Prolong component life reduce maintenance
- Improved catalyst life

SilcoKlean® 1000 Features

- Resists carbon fouling/coking

SilcoKlean® 1000 Benefits

- Reduced maintenance increased productivity

Analytical Instrumentation

SilcoTek® customers:

Analytical instrument manufacturers, testing laboratories, research facilities, detection system manufacturers, environmental labs, universities.

SilcoNert® 2000 Features

- Inert sample pathway
- High temperature capability
- Unmatched high purity inertness
- Easy clean, non-stick surface
- Low moisture retention

SilcoNert® 2000 Benefits

- Low level detection & reproducibility
- Durable/low maintenance cost
- High productivity, low sample loss
- Low maintenance cost
- High test yield/lower cost

Bio/Pharmaceutical

SilcoTek® customers:

Pharmaceuticals, health care products companies, device manufacturers, universities.

Dursan® Features

- Prevents adsorption
- High temperature capability
- Unmatched high purity inertness
- Easy clean, non-stick surface
- Low moisture retention
- High release

Dursan® Benefits

- Low friction
- Durable/low maintenance cost
- Extended component life
- Low maintenance cost
- High test yield/lower cost

Power Generation

SilcoTek® customers:

Coal fired electric utilities, emissions monitor instrument manufacturers, mercury emission monitor manufacturers, emission systems installers and integrators, stack testing firms, engineering firms, consumable suppliers of stack probe equipment.

SilcoNert® 2000 Features

- Inert silicon treatment
- High purity, non reactive, moisture repelling surface

SilcoNert® 2000 Benefits

- Insure accurate NOx, SOx, Mercury emissions monitoring
- Reliable sample transfer, improved CEMS performance

Silcolloy® 1000 Features

- High temperature inert treatment
- High temperature corrosion resistance
- May resist hydrogen permeation/embrittlement

Silcolloy® 1000 Benefits

- Durable, reliable sample transfer
- Improved stack probe and filter life
- Increased component life, lower costs

SilcoKlean® 1000 Features

- Reduces carbon fouling/coking

SilcoKlean® 1000 Benefits

- Reduce de-coking frequency, lower plant costs

Resources

Most Popular:

- White paper – *Improve Sample Reliability*
- Application Guide
- Material comparison – Dursan vs. SilcoNert
- Blog

White papers

Application Notes

FAQ

Free Test Coupon

We hope you enjoyed SilcoTek® 101.

Let us know your thoughts: _____

Lit. Cat. ST-012

Coatings that Expand Material Limits™

SilcoTek's patented coatings solve the most demanding material challenges found in energy, science, and technology industries.

Features

- Chemically inert
- Corrosion resistant
- Flexible, won't flake
- Thin (<1000 nm)
- Hydrophobic
- Easy to clean
- High temperature

Advantages

- 3D, non-line-of-sight process
- Significant cost savings over exotic alloys or materials
- Enables trace analysis required for regulatory compliance
- Easy to integrate from prototype to production

Benefits

- Improve system efficiency and uptime
- Decrease maintenance
- Increase productivity
- Save money

SilcoTek®

Innovative surface coatings that make the impossible possible

Bring robust corrosion resistance and chemical inertness to the molecular level of stainless steel, glass, ceramic, and other substrates.

FOR CHEMICAL ANALYSIS

SilcoTek's silicon-based coatings are specially tailored for inertness (non-reactivity) to highly active chemical compounds. Required for analyzing trace levels of sulfurs, mercury, emissions, pesticides, etc.

SilcoNert® is the industry-preferred coating for highly sensitive sampling and analysis applications. Dursan® is a tough and versatile coating suited for harsh analytical environments. Modern chemical detectors and analyzers manufactured worldwide rely on these inert coatings to give accurate results.

FOR CORROSION PROTECTION

Protect critical investments in a wide array of corrosive environments. SilcoTek's dense, pinhole-free coatings provide a uniform, molecularly-bonded barrier between substrate and flow path.

Dursan includes oxygen and carbon in the base silicon layer for a ceramic-like, durable, and highly corrosion resistant coating. Suited for pH 0-14 and harsh corrosives like HCl, H_2SO_4, bleach, and more. Silcolloy® adds significant potential lifetime to parts in oxidative environments. Bring exotic alloy performance to stainless steel for a fraction of the cost.

FOR HIGH PURITY

Prevent leaching of metal ions from stainless steel equipment into critical process streams while increasing system uptime. Imperitive in sensitive manufacturing environments e.g. semiconductor.

Silcolloy offers oxidation, chemical, and corrosion protection even at temperatures as high as 1000° C. Dursox™ is a silica-like coating with exceptionally low surface energy and high durability. SilcoGuard® greatly reduces outgassing in high vacuum applications. All three coatings provide better equipment lifetimes and higher product yields to companies with strict purity requirements.

CHOOSING THE RIGHT COATING

Customers should work with SilcoTek's technical experts to help them select the best coating for their application. Some applications require a very specific treatment whereas any SilcoTek coating could work for others. SilcoTek's complete line of coating solutions offers a multitude of surface properties in addition to what's highlighted above:

- Low surface energy
- Anti-coking/anti-fouling
- Hydrophobicity
- Abrasion resistance
- Easy cleaning/anti-stick
- Low outgassing

The recommendation process often involves samples, testing at both customer and SilcoTek sites, technical consultation, visits, and more. The SilcoTek service experience couples technical expertise with coating capability and performance to give customers a solution they (and their customers) can rely on.

Coating Properties

SilcoTek's innovative chemical vapor deposition (CVD) process introduces proprietary process gases into a special oven containing your parts. The gas penetrates torturous passageways and provides a thin, uniform coating even on complex part geometries.

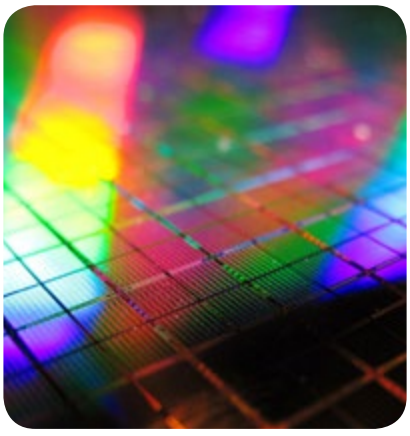
Each standard SilcoTek® coating is tailored to specific applications but can be used successfully in a wide variety of environments. Contact SilcoTek for coating recommendations.

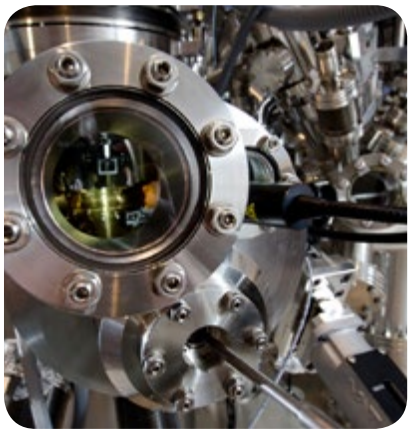
COATING	MATERIAL COMPOSITION	MAXIMUM TEMPERATURE	CONTACT ANGLE*	WHAT IT DOES
SilcoNert® Superior inertness	Silicon (functionalized)	450° C	99°	Makes surfaces non-reactive. A durable, high temperature alternative to fluoropolymers like PTFE or PFA.
Dursan® Corrosion and abrasion resistant, inert, low surface energy	Silicon, oxygen, carbon (functionalized)	450° C	119°	Provides low surface energy and excellent protection in very corrosive environments. Hydrophobic, 2x as wear resistant as stainless steel and easy to clean.
Silcolloy® Oxidation resistant, high temperature	Silicon	1000° C	54°	Protects parts from oxidation while preventing metal ions from leaching out of surfaces. Ideal for high temperature applications.
SilcoKlean® Anti-coking	Silicon (functionalized)	1000° C	90°	Prevents hot fuels and gases from coking or fouling on metal surfaces. Ideal for fuel transfer and exhaust gas applications.
SilcoGuard® UHV low outgassing, high purity	Silicon	1000° C	54°	Isolates materials trapped on or in metal surfaces and prevents them from entering ultra-high vacuum or other high purity environments.
Dursox™ Silica-like, ceramic	Silicon, oxygen** (functionalized) **<2% embedded carbon	450° C	<60°	Gives durabilty, moisture resistance, erosion and corrosion protection to processing equipment. Ideal especially for semiconductor manufacturing equipment.

*Evaluated on 120 grit, 58 rms (µin.) 300-series stainless steel

A Note on Thickness

SilcoTek's chemical vapor deposition (CVD) process has been optimized to produce surface coatings that meet the performance characteristics and material properties listed above, unrelated to thickness. All coatings are typically less than 2000 nm (2µm) thick.





Industries & Applications

Petrochemical

- Process analyzers
- CEMS
- Ethylene and propylene
- Refinery, flare, and stack gas
- ULSD/ULSG
- LNG and CNG
- Environmental sampling

Oil and Gas Exploration

- Well sampling
- Downhole tools
- Offshore instrumentation
- Odorant testing
- Wireline
- Power generation and distribution

Semiconductor Manufacturing

- Etch and deposition
- Epitaxy
- MOCVD and PECVD
- CMP
- OLED
- Ozone
- Moisture analysis

Aerospace and Automotive

- Fuel and injector nozzles
- Feed lines
- Fuel injectors
- Exhaust testing
- Exhaust gas recirculation equipment

Analytical

- Chromatography
- Needles and probes
- Vials
- Sample loops
- Ultra high vacuum
- Flow control
- Food and beverage analysis

Coatings that Expand Material Limits

Whether in the laboratory, plant, or field, SilcoTek's patented coating technologies provide advanced material solutions that save you time, increase your productivity and improve performance, all while lowering operating costs and protecting your critical investments.

SilcoNert® **Dursan®**

Silcolloy® **Dursox™**

SilcoKlean® **SilcoGuard®**

For more information, visit www.SilcoTek.com

Coating Use

All statements, technical information and recommendations contained in this document are based upon tests or experience that SilcoTek believes are reliable. However, many factors beyond SilcoTek's control can affect the use and performance of a SilcoTek coating in a particular application, including the conditions under which the product is used and the time and environmental conditions in which the product is expected to perform. Since these factors are uniquely within the user's knowledge and control, it is essential that the user evaluate the SilcoTek coating to determine whether it is fit for a particular purpose and suitable for the user's method of application.

Limited Liability

Except where prohibited by law, SilcoTek will not be liable for any loss or damage arising from the SilcoTek coating whether direct, indirect, special, incidental or consequential, regardless of the legal theory asserted, including warranty, contract, negligence, or strict liability.

Patents and Trademarks

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Information subject to change without notice.

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