SilcoTek Coating Success and Care Guide

Please review this guide with your salesperson before sending your parts to SilcoTek for the first time. This document also contains important information for maintaining, cleaning, and using your coated parts after receiving them back from SilcoTek.

Since 2009, SilcoTek has been a leading global provider of performance coatings and surface treatments for high technology industries. SilcoTek provides cutting edge chemical vapor deposition (CVD) barrier coating technology, passivation services, as well as cleanroom packaging services to our customers in semiconductor, analytical, life sciences, and energy markets.

Before You Send Your Part to SilcoTek, You Should Know:

- Your part will be exposed to process temperatures ranging between 400-450°C.
  - Outgassing (vaporization, degradation) at these temperatures will interfere with proper SilcoTek deposition
  - Inorganic residue / contamination on the surface will interfere with proper SilcoTek deposition
- SilcoTek will prepare the surface to the best of our ability. Unless previously qualified, your part will be exposed to sonicated alkaline (NaOH-containing surfactant) or acidic (citric acid-containing) solutions, or both, for proper surface preparation of our deposition processes.
  - Alternative surface preparation techniques may be used by SilcoTek for unique situations (solvents, heat, vacuum anneal, thermal oxidation in air.)
- A successful CVD coating application begins with a compatible customer part. Please reference SilcoTek's material compatibility guide and carefully read this guide to ensure parts arrive clean, compatible, disassembled, with all synthetic parts removed, and ready for treatment.

Surface Preparation

SilcoTek typically recommends that customers do not perform any precleaning of parts. Depending on what is used to "clean" a part and how it is performed, precleaning can do more harm than good in preparation for our deposition services. Please consult with our experts regarding precleaning strategies. With that stated, the following are some standard precleaning recommendations:

- Commercial cleaning solutions: SilcoTek does not recommend any "over the counter" cleaning solutions nor household detergents (e.g. Simple Green, Dawn). They are not sufficient cleaners and can be very difficult to completely rinse from the surface, leaving behind an invisible residue that cannot be easily removed and will often become visible stains after the CVD coating process.
- Alkaline solutions of degreasing detergents containing NaOH or KOH in high purity deionized water may be acceptable to remove contaminants from compatible substrates such as stainless steels and nickel alloys. Alkaline solutions are not compatible with some substrates such as aluminum.

- Acidic: Organic acid cleaners containing citric acid may be acceptable as well but are incompatible with certain substrates such as carbon steels.
- Solvents: Standard organic solvents, particularly those known to solvate known contamination on a part are acceptable for use.
- Additional energy such as heated solutions and sonication can also be used to preclean. However, beware of physical damage (pitting) from intense sonication and touchpoint damage during sonication. Heated baths can improve cleaning efficiency but can also accelerate potential damage to a substrate.
- The number one key to surface preparation is to never allow a cleaning solution to dry on to the substrate surface. It is imperative that any cleaning solution is thoroughly rinsed with high purity, deionized water while the part is still wet with the cleaning solution. Never use city or tap water as they contain minerals and additives that will leave behind residues and contamination that are then difficult to remove by SilcoTek surface preparation.

What Substrates and Materials Can SilcoTek Coat?

- Substrates: Some substrates are incompatible with our deposition processes. The Substrate Compatibility List is not exhaustive and is updated as needed. A customer may introduce a new material that is not compatible, or SilcoTek may develop a new process that allows us to deposit on substrates that were previously not compatible (i.e. Monel).
  - Not all steels are created equal, stainless steel quality matters.
- Welding recommendations: TIG welding with no filler is optimal.
- Brazing and soldering considerations. Vacuum nickel brazing is optimal.
- O-rings and compression connections:
  - O-rings and all polymeric seals are not thermally compatible with SilcoTek processing and must be removed prior to processing.
  - SilcoTek recommends that compression connections are disassembled prior to processing but can remain connected if necessary. Consult with our experts.

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Part Surfaces

Surface Finishes

- Electropolished surface coating considerations:
  - Thorough rinsing and neutralization are the key to having a properly coated electropolished surface.
  - Passivation is a highly recommended post-electropolish treatment to improve corrosion resistance and preparation for SilcoTek coating. See more under SilcoTek Treatment Processes.
  - Dry electropolish process considerations: If performed improperly, dry electropolishing will leave invisible microdeposits of the electrolyte bead resin (typically styrene / divinylbenzene copolymer) on the part surface. Dry electropolished parts must be properly rinsed post-processing to ensure a surface without any copolymer residue. Contact your dry electropolish provider for proper guidance.
- Buffing/mechanical finishing: As mentioned in ASME BPE specifications, mechanical buffing as a final polishing finish may trap buffing compound underneath microfolds in the surface which may then cause poor coating growth and/or adhesion. Even thorough rinsing with hot DI water after polishing will likely not mitigate contamination risks.
- Surface roughness: SilcoTek processes will effectively coat any level of surface roughness/smoothness without changing surface finish designation (e.g. ASME BPE.) Surface cleanliness is the primary driver for a successful coating process.
- Brass crossover contamination from shared cutting tools: If a machine shop works both brass and stainless-steel parts, shared tooling from brass processing will embed brass microparticles (which contain copper) in to the stainless steel parts. This results in poor coating.
- Cutting oils/cooling fluid and brass contamination: If cooling/cutting fluids are shared among tools used to machine both brass and stainless-steel parts, the brass-contaminated fluid will allow brass to embed within machined stainless steel.
- Wire EDM: Do not use brass as the EDM wire.

Pre-used or Precoated Parts

Pre-used parts may retain contamination.

- Field-use contamination: If a part has been in use and retains process contamination, SilcoTek requires the customer to fill out a declaration of health and safety (contact Customer Service). This is to ensure the safety of SilcoTek employees during the receiving and surface preparation of customer parts. It also allows us to determine the optimal surface preparation strategy.
- Rust:
  - Iron oxide rust is not compatible with SilcoTek processing, and coating over the top of it will result in localized: delamination, incomplete deposition, active sites for corrosion initiation, and/or poor inertness.
  - Additional treatments can be applied to remove rust prior to shipment to SilcoTek.

Precoated parts should see the following for compatibility adherence.

- Metal plated surfaces (and other pure metals). See Substrate Compatibility List.
- Copper plate (and pure copper) is not compatible, but many copper alloys like Monel can be coated. It is important to know if copper is present as SilcoTek needs to use proper protocol to process these alloys.

- Nickel plate is not compatible (but nickel alloys are compatible; consult SilcoTek for coating pure nickel, recent advances may allow for coating).
- Galvanized metal (and any significant concentration of Zinc in particular) is not compatible.
- Silver/gold plating is compatible if the metal is pure and of high quality. Please contact us for more information.
- Chromium plate is usually compatible.
- Delamination due to a TCE (thermal coefficient of expansion) mismatch can be a potential risk when placing a SilcoTek coating over another coating.
- CVD/PVD/ALD/Anodized
  - SilcoTek has successfully coated over several different types of other depositions. Please consult with our experts.
  - Coating anodized aluminum is possible when anodization is performed properly.
    - Dyes that are commonly applied to aluminum after the anodization process are incompatible with our process.
- Paint/labels/silicones/waxes/greases/epoxies/caulk/sealants
  - These materials are incompatible with SilcoTek processing and must be removed by the customer prior to coating.

Pre-heating Treatment of Coated Parts for High-Temperature Applications

For high temperature applications where stainless steel parts will exceed 700°C in use, we recommend heat treatment prior to our coating process. SilcoTek works with a vacuum heat treating service provider near our facility in Pennsylvania to perform this process that has shown great results after our coating. This pre-heat treatment is recommended to harvest the full potential of SilcoTek's silicon coating for high temperature applications. The data behind this recommendation can be found here.

Pre-Coating Preparation Capabilities

Citric Acid Passivation Services

- When applicable (based on part size and end-use), SilcoTek will passivate stainless steel parts using citric acid per ASTM method A967 prior to coating. Surface cleanliness is critical to coating success, and passivating metal parts before coating creates an optimized coating surface to increase corrosion resistance and overall performance of coated parts. SilcoTek's passivation services include Citric 2 Passivation per ASTM A967 standards, sonicated tanks with flow-through capability, forced air drying, and robust quality assurance and control using copper sulfate tests. For more information on passivation for corrosion protection, click here.

Surface Preparation and Precision Cleaning Services

- SilcoTek surface preparation methods are designed to minimize contamination from oils and other contaminants. Customers requiring additional cleaning methods should notify SilcoTek for requirements beyond the following methods:
- Vapor Stripping – Precision cleaning; size limitations apply.
- Ultrasonic Cleaning – Precision cleaning in ultrasonic cleaning baths.

Metal Working

- Tubing cutting and deburring services.
- Tooling/fixturing design and fabrication.

Material Analysis Capabilities

SilcoTek has an array of material analysis services that may be available upon request to our customers depending on their application needs. Capabilities include:

- Fourier Transform Infrared Spectroscopy (FT-IR): Nicolet Model iS20
- Filmetrics F20 and F40 Spectroscopic Thickness Analysis
- Electrochemical Impedance Spectroscopy (EIS): Gamry Series G 300 Potentiostat/Galvanostat
- Goniometer: Ramé -Hart Model 200
- Tensiometer: Kruss K100
- Cyclic Salt Fog Chamber: Weice Testing Instrument WTS90+C
- Non-destructive Metal Composition Analysis: Evident Vanta and Niton XL3 XRF Analysis

SilcoTek staff scientists are also trained to work with our partners and neighbors at Pennsylvania State University to conduct further in-depth analysis using the following services:

- Raman spectroscopy to analyze coating crystallinity and bonding moieties.
- ICP-MS to measure coating purity and barrier performance.
- TEM for assessing coating microstructure and layer thicknesses.
- XPS to analyze coating composition and depth profile
- SEM/EDS to assess surface coverage, composition, and purity.
- AES to analyze coating composition and depth profile
- FIB SEM or TEM for thickness and layer analysis.
- Profilometry for surface roughness analysis.

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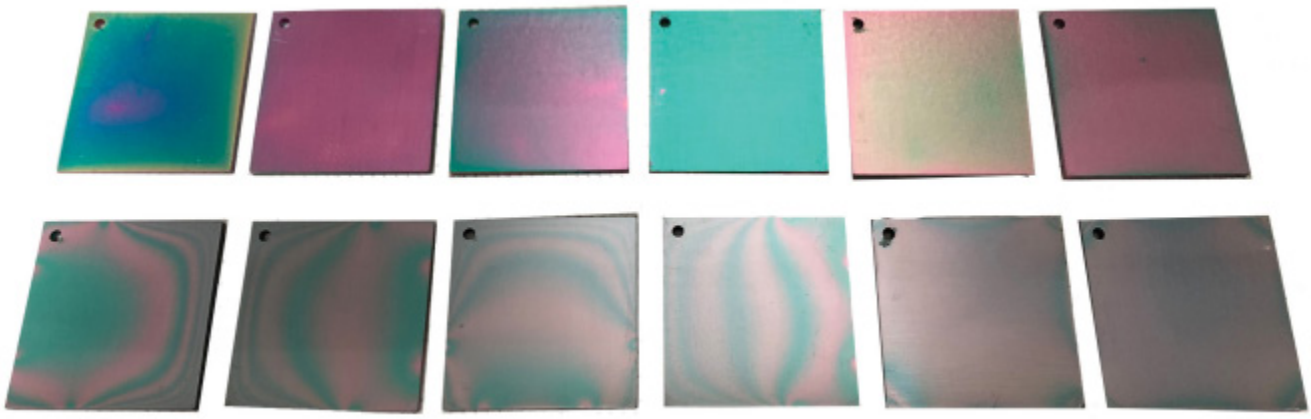
Appearance

Typical Appearance of SilcoTek Coatings

The colors of SilcoTek's coatings are a result of light adsorption and/or refraction through the thin film of the coating on a substrate. A slight change in thickness (a few nm) changes the interference pattern of the light, creating a big impact on the visible colors. The process of light adsorption and/or refraction gives our coatings their signature rainbow appearance.

The surface finish should be bright and free of defects; however, the original surface condition can have a major impact on final surface quality. Customer parts are prepared before and after treatment to ensure optimal aesthetic quality. Sometimes the part surface may contain trace silicon (black particles) as a byproduct of the silicon-based CVD treatment process. Residual silicon can be removed by simply rinsing with a solvent or by sonication in water.

SilcoTek Coating	Typical Thickness	Typical Appearance
SilcoNert 1000	100-500 nm	Rainbow
SilcoNert 2000	100-500 nm	Rainbow
Silcolloy 2000	580-2400 nm	Matte
SilcoKlean	100-500 nm	Rainbow
Dursox	400-1600 nm	Rainbow
Dursan	400-1600 nm	Rainbow
Siltride	500-2000 nm	Rainbow
Notak 2000	No appreciable thickness	Clear (stainless steel will oxidize)



The typical thickness ranges shown above are representative measurements obtained from SilcoTek sample coupons under controlled coating conditions and are provided for reference only. Typical thickness is not a product specification and may vary based on part geometry, surface characteristics, fixturing, quantity, and other processing factors. Variations within normal coating process parameters do not adversely affect coating performance.

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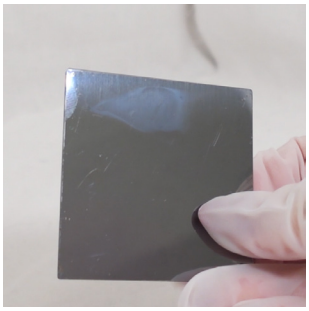
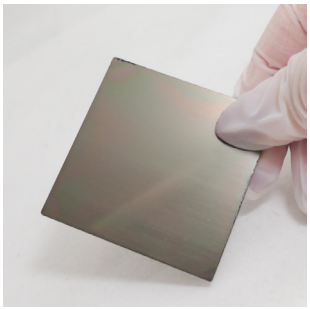
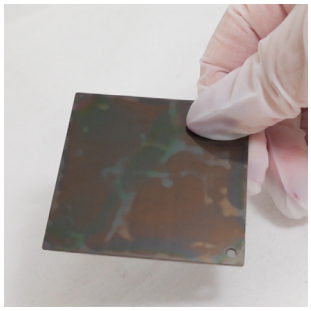
Typical Cosmetic Anomalies

What is a cosmetic anomaly?

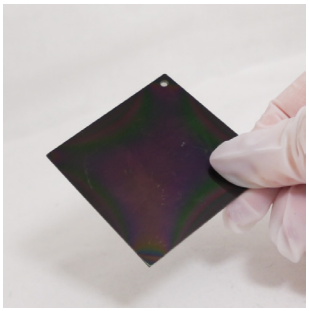
SilcoTek coatings are susceptible to typical cosmetic anomalies due to the nature of our coating process. Our quality control technicians are trained to inspect coated parts for flaws that will affect part performance, in which case the customer will be notified and further troubleshooting steps will be taken. This document will demonstrate common visual anomalies that customers may notice, but our quality team has deemed acceptable as they should not affect part or coating performance. For example, carbon steel will naturally oxidize in the high temperatures of our coating process and appear much darker than uncoated. However, the part remains fully functional and the coating is unaffected. See below for more examples of typical cosmetic anomalies that do not affect performance. For any questions regarding appearance, please contact SilcoTek directly.


Cleaner residue, produces visual cloudiness.

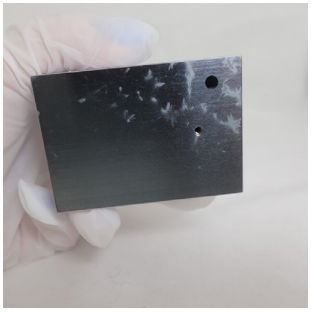

Haze, overall cloudiness.

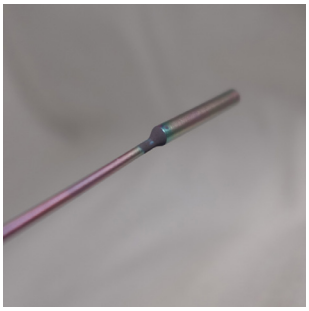

Mottling, random pattern.

Non-raised halo.

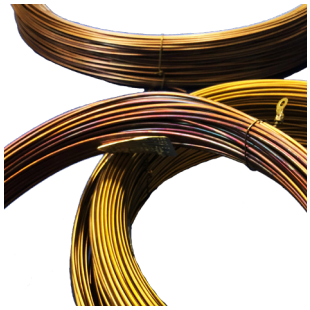

Carbon steel darkening.

Fixturing touchpoint.


Aluminum discoloration.


Discolored braze joint.

Milky residue.


Oxidized coated tubing.

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Maintaining and Troubleshooting Coated Parts

Troubleshooting Coated Parts

Under normal use, SilcoTek-coated parts should deliver excellent performance for years to come. However, effective lifetime is dependent on the severity of the environment. Factors that can affect performance include:

- Contamination – Failure to properly clean the surface can allow increased surface activity. If performance changes, properly clean the surface and inspect the layer for damage.
- Erosion – Contact with abrasives can accelerate surface wear and ruin coating performance.
- Bases – Contact with a base (>8 pH) can accelerate deterioration of silicon coating layers (SilcoNert, Silcolloy, SilcoKlean) and ruin coating performance.
- Surface Finish – Surface finish and color should stay consistent throughout the life of the product. Changes can indicate a partial loss or a chemical change of the coating layer.
- Abuse – Damage to parts may require part and coating replacement.

Cleaning

- When cleaning a treated part, rinse with a solvent that will dissolve probable surface contaminants (i.e., use a nonpolar solvent to remove hydrocarbon contaminants, or a more polar solvent to remove more active contaminants.)
- Avoid using cleaners containing abrasives as they can scratch the layer. Mild sonication may assist in contaminant removal, but do not oversonicate as this could damage the layer.
- Solids can be removed with a soft nylon bristle brush using light pressure.
- Do not use basic solutions or soaps with pH>8.
- Your parts are inspected to meet our quality standards and cleaned after treatment; however, the surface may contain some trace silicon (black dust particles) as a byproduct of the treatment process. Residual silicon can be removed by rinsing with a solvent like IPA or sonication in water.

Steam Cleaning and Autoclave Exposure

In order to gain a better understanding of the effects of steam and autoclave environments on SilcoTek coatings, SilcoTek performed a series of tests on coated coupons to measure water contact angle (WCA), coating thickness, and FT-IR spectroscopy. The following suggestions are made with those test results in mind.

Coating Family	Summary	Stability in Steam/Autoclave Environment
Silco- coatings (SilcoNert and Silcolloy variations)	No appreciable thickness change, significant surface e oxidation, significant decrease in WCA, measurable increase in Si-O-Si absorbance.	Poor
Dur- coatings (Dursan and Dursox variations)	No appreciable thickness change, slight decrease in WCA and slight increase in Si-OH functionality.	Good
Siltride coatings	No appreciable thickness change or FT-IR spectra effects. Excellent resilience.	Excellent

Siltride Hydrophilic Surface Restoration

Like most hydrophilic surfaces, Siltride is susceptible to gradual increased water contact angle while stored in air over time, due to adsorption of organic species from the atmosphere. SilcoTek recommends annealing in air or an inert atmosphere at ≥ 400°C (for a few minutes to up to an hour) or exposing the coated surface to a dilute (e.g. 5%) NaOH solution for a few minutes to restore the original water contact angle.

Galling and Sealing Considerations

Galling can occur when two parts of similar material are connected under compression and the heat generated essentially "cold welds" the parts together. Customers have occasionally observed galling when two SilcoTek treated compression fittings or NPT fittings are assembled. Occasionally, mating coated threaded parts can cause leaks. Galling and leaking do not occur when uncoated threads are mated to SilcoTek-coated threads.

- SilcoTek does not recommend coating the nuts or ferrules from compression fittings.
- SilcoTek recommends removing the coating from male threads with Scotch Brite or applying PTFE tape when two NPT fittings are connected.
- If both mating parts must be coated, SilcoTek recommends using anti-seize compounds made from silver, moly, or nickel.
    - For sample cylinder applications, refer to the instructions pertaining to the use of PTFE tape on the valve NPT prior to installation.

Important Reminder

Please review this guide with your salesperson to discuss any questions or concerns before sending your parts to SilcoTek for the first time. Customers can reach the team by calling +1 814-353-1778 or emailing SilcoTek at TechService@SilcoTek.com.