



**SilcoTek**®

**SilcoTek High Purity Coatings**  
from science to performance

# Why use coatings?

- High Purity
  - Reduce system corrosion
  - Eliminate ion contamination
  - Reduce moisture effects
  - Reduce vacuum pump down time



# Applications for High Purity SilcoTek Coatings

- Bio/pharma
- Analytical
- Semiconductor manufacturing
- Vacuum, and more

# SilcoTek Solutions

- **Silicon-based**

- Silcolloy

- US Patent #7,070,833
- Amorphous, hydrogenated silicon (a:Si-H)
- 400-800 nm typical thickness

- **Silicon oxide-based**

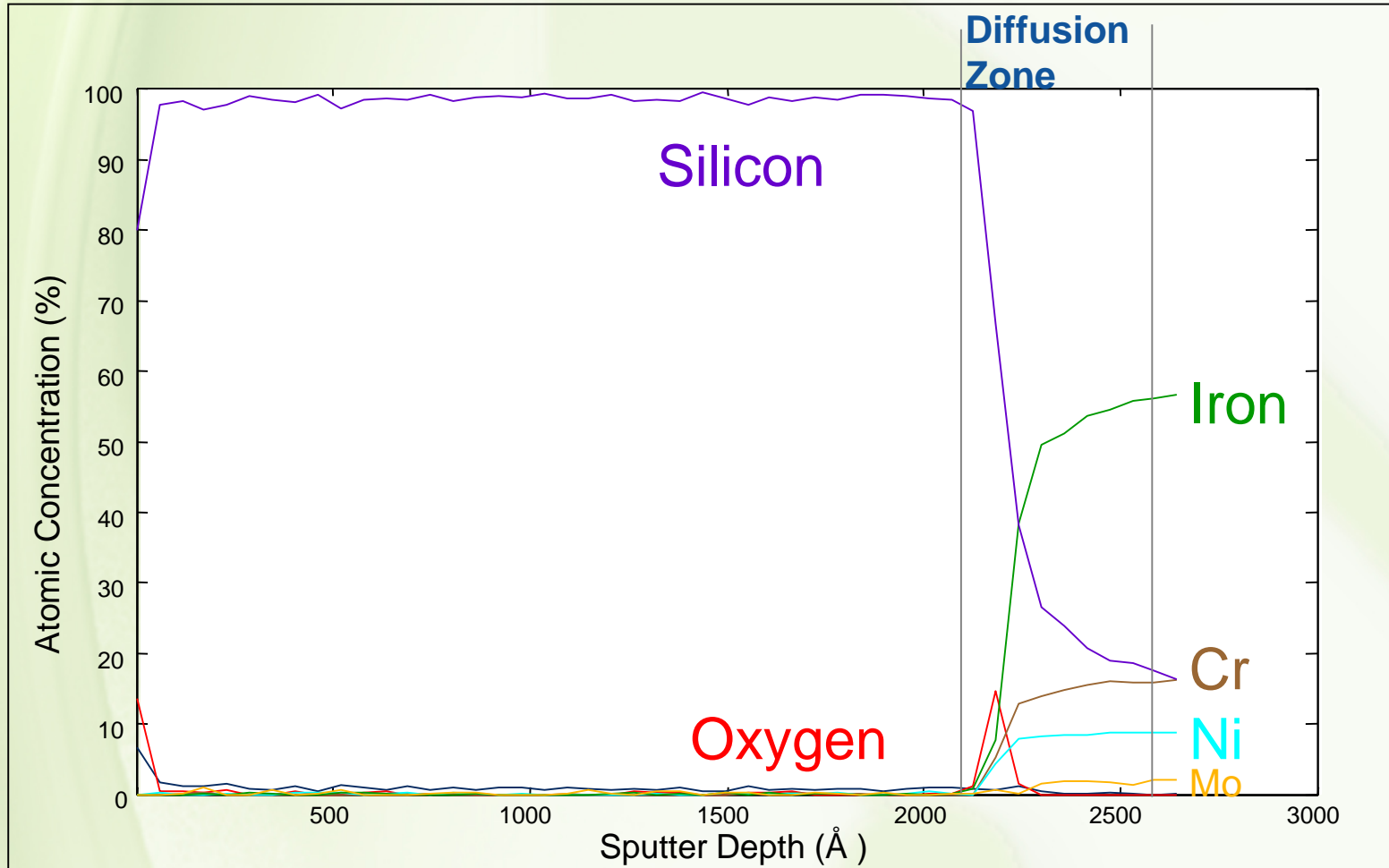
- Dursan

- US Patent Pending
- Silicon oxide from organic source gas
- 300-1500 nm typical thickness
- Functionalized and non-functionalized available

# Process Outline

- **Coatings applied to stainless steel and chrome/moly/nickel alloys**
- **Chemical Vapor Deposition process**
- **Customer supplied parts**
  - Either direct from OEM (mass flow controllers/regulators)
  - End user (custom components)
  - Fabricators (weldments/assemblies)
- **Surface Preparation**
- **Vacuum deposition process**
  - Non-line-of-site
  - Batch process
- **100% inspection**
- **Return**

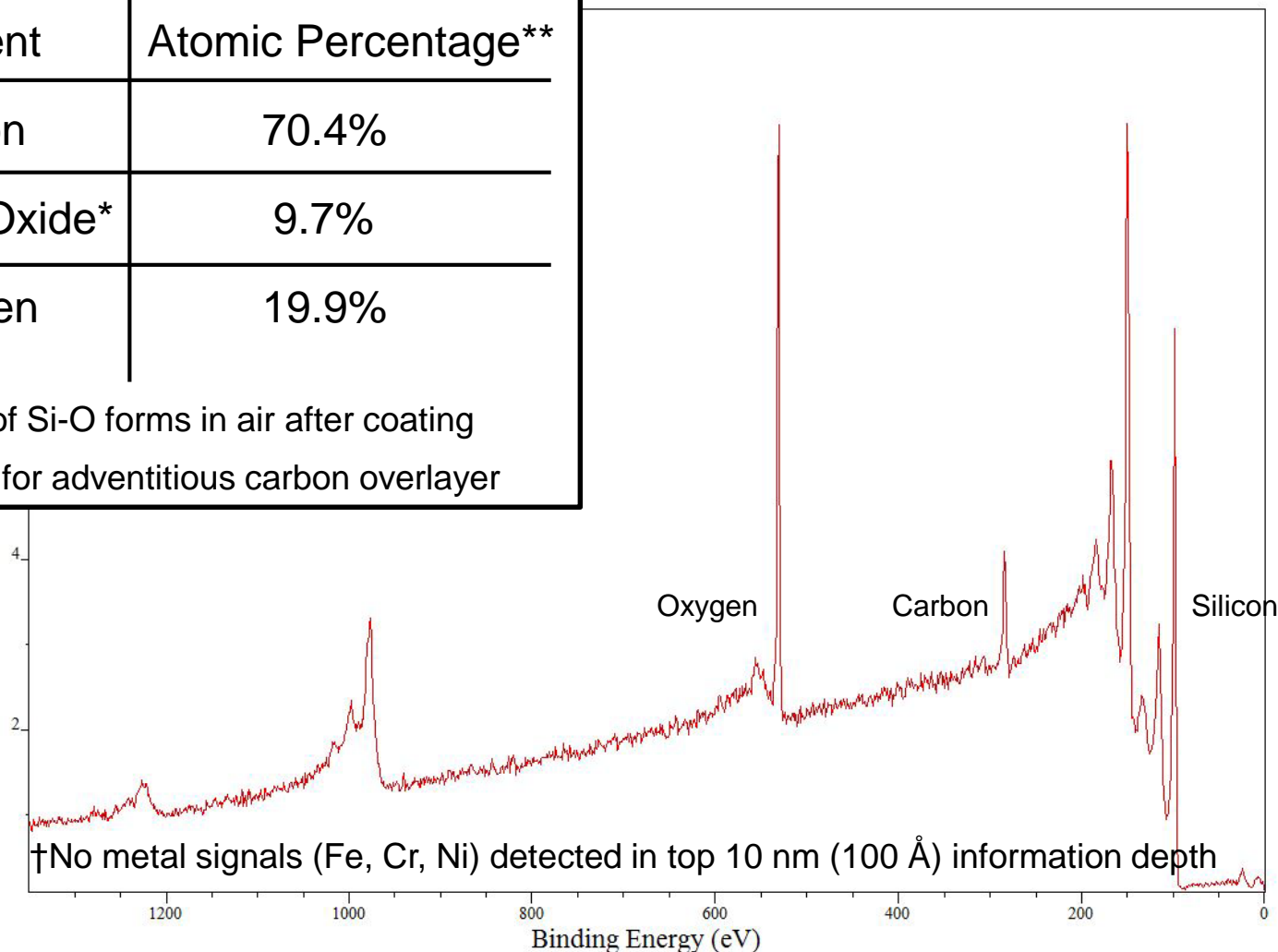
# Silicon-based Coatings



# Silicon-Oxide Dursan

Element	Atomic Percentage**
Silicon	70.4%
Silicon-Oxide*	9.7%
Oxygen	19.9%

\*Thin layer of Si-O forms in air after coating  
 \*\*Corrected for adventitious carbon overlayer



Technique:  
 X-Ray Photoelectron Spectroscopy (XPS)

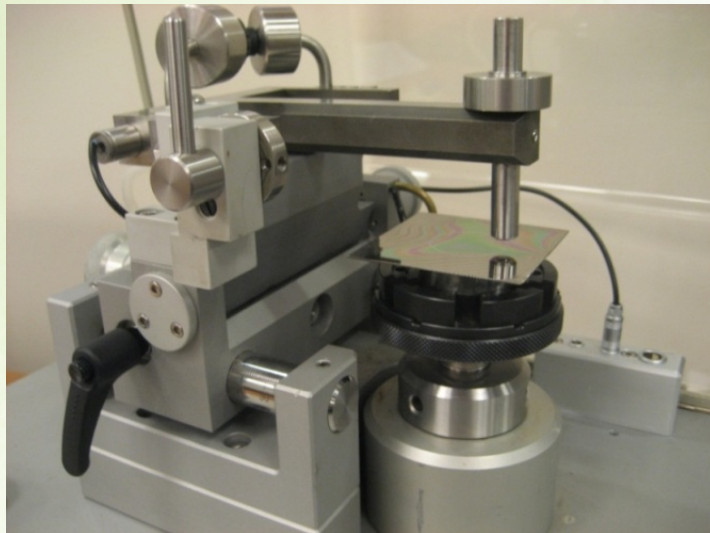
# Physical Properties of CVD coated surfaces



# Wear and Friction

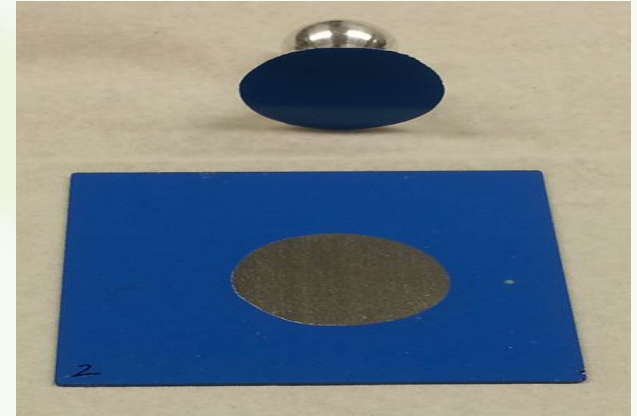
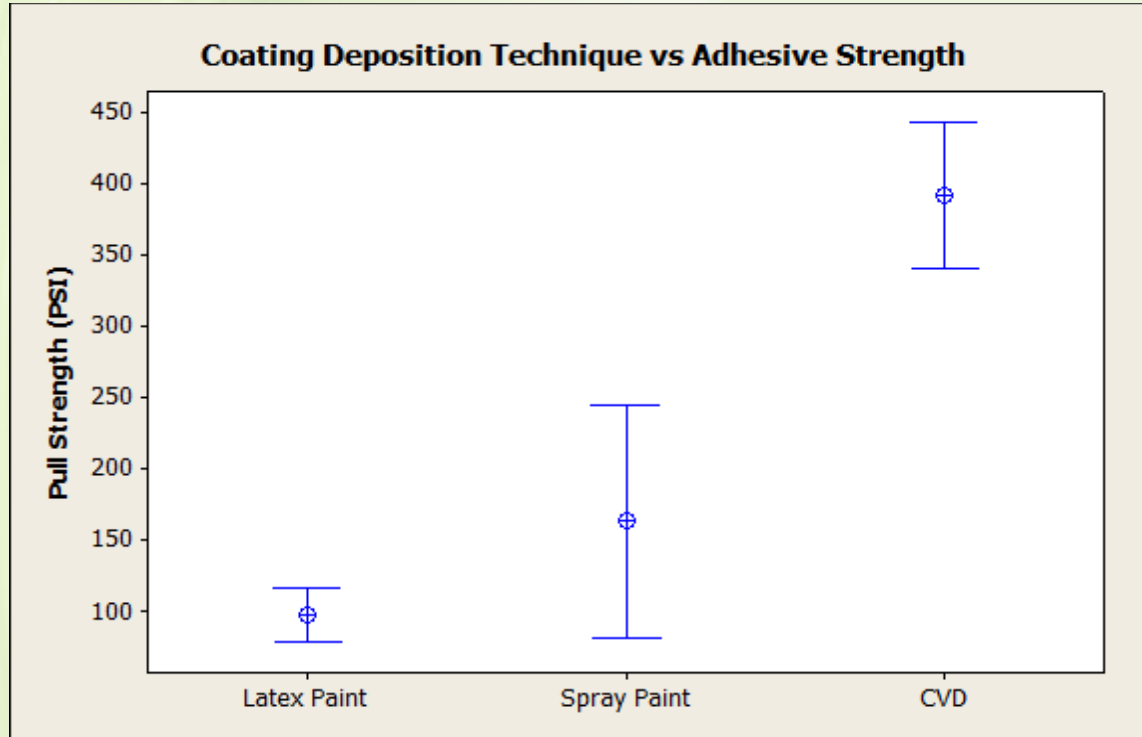
	<u>Avg. Coeff. Friction</u>	<u>Wear Rate (x10<sup>-5</sup>mm<sup>3</sup>/Nm)</u>
Uncoated SS	0.589	13.810
Si <sub>x</sub> O <sub>y</sub> -base (functionalized)	0.378	6.129
Si-base (corrosion)	0.7	14.00

- ASTM G133 (Pin-on-Disc)
- Mirror Finish 316L SS



Experimental Parameters	
Load	2.0 N
Duration	20 min
Speed	80 rpm
Radius	3mm
Revolutions	1,554
Ball Diameter	6mm
Ball Material	SS 440

# CVD Coating Solutions



# Material Properties Sheet

Property	Si-Based	Si <sub>x</sub> O <sub>y</sub> -Based	PTFE, PFA
Max Temperature	900°C	450°C	260°C
Min Temperature	-196°C	-100°C	-240°C
Low pH limit	0	0	0
High pH limit	7	14	14
Thickness	0.12um to 0.8um	0.3um to 1.5um	25um
Adhesion	Very Good	Very Good	Poor
Wear resistance	~90% of SS	2x SS	~10% of SS
Moisture contact	72-90°	104-140°	125°
Inertness vs. SS	Excellent	Good	Excellent

# Corrosion Resistance

# Corrosion Resistance

- **Challenges**

- Physical Losses
  - Maintenance & Replacement Cycles
- Increased Activity
- Metal Contamination

- **Solutions**

- Extended Lifetimes
- Lower Reactivity
- Substrate Barrier

# Corrosion Testing Results (ASTM G31)

	6M HCl		3M HCl		1M KOH		10% Sulfuric	
	MPY rate	factor	MPY rate	factor	MPY rate	factor	MPY rate	factor
316L SS	161.4	-	67.93	-	0.00	-	22.35	-
Dursan	2.2	75	5.14	13.2	0.01	261	2.42	9.9
Silcolloy	3.6	45	14.85	4.6	0.01	Dissolved	2.52	8.9

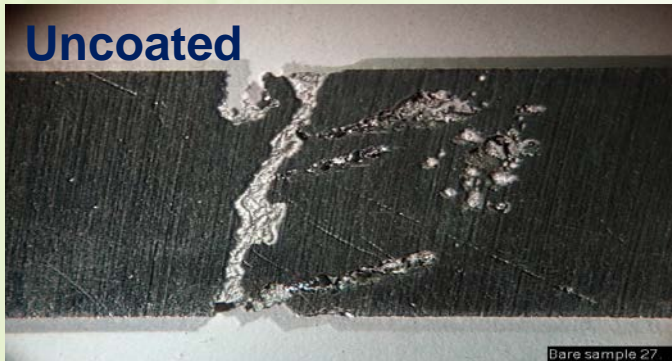
# Corrosion Testing Results (ASTM G31)

	5% HF		70% Nitric		85% Phosphoric		25% Sulfuric	
	MPY rate	factor	MPY rate	factor	MPY rate	factor	MPY rate	factor
316L SS	120.00	-	0.78	-	0.62	-	54.64	-
Dursan	80.38	1.49	0.10	7.50	0.08	8.00	5.36	10.19
Silcolloy	44.26	2.71	0.36	2.14	0.28	2.18	23.62	2.31

# Corrosion Testing Results (ASTM G48B)

Sample	Initial Weight (g)	Final Weight (g)	Weight Loss (g)	Weight Loss (g/m <sup>2</sup> )
Silcolloy Sample 17	10.4105	10.3710	0.0395	19
Silcolloy Sample 28	10.1256	10.0743	0.0513	25
Silcolloy Sample 47	10.1263	10.0742	0.0521	25
Bare Sample 27	10.0444	9.5655	0.4789	231
Bare Sample 34	10.1265	9.6923	0.4342	209
Bare Sample 37	10.1007	9.6276	0.4731	228

**Uncoated**



**Coated**



## Pitting & Crevice Corrosion

- 6% Ferric Chloride
- 72 hrs @ 20C
- Gasket Wrapped



# Corrosion Testing Results (ASTM B117)

## Salt Spray

- **4000 hour exposure**
  - 100 F
  - 3.5% by weight sodium chloride
- **No Effect on Silcolloy Coating**
- **Reproduction of Exposure to Marine Environments**

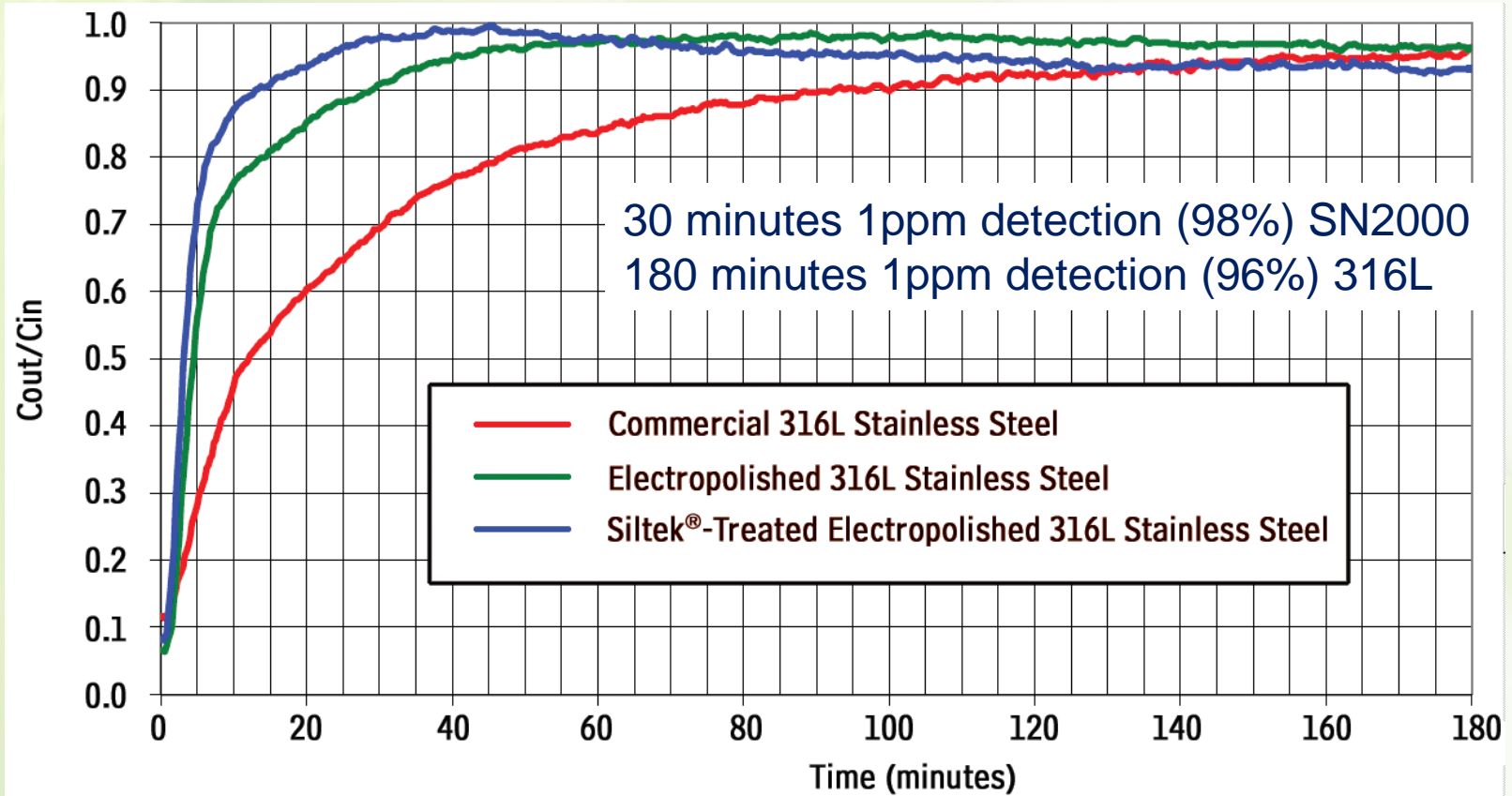
**Reduce cross contamination,  
carryover and adsorption**

# Chemical Inertness

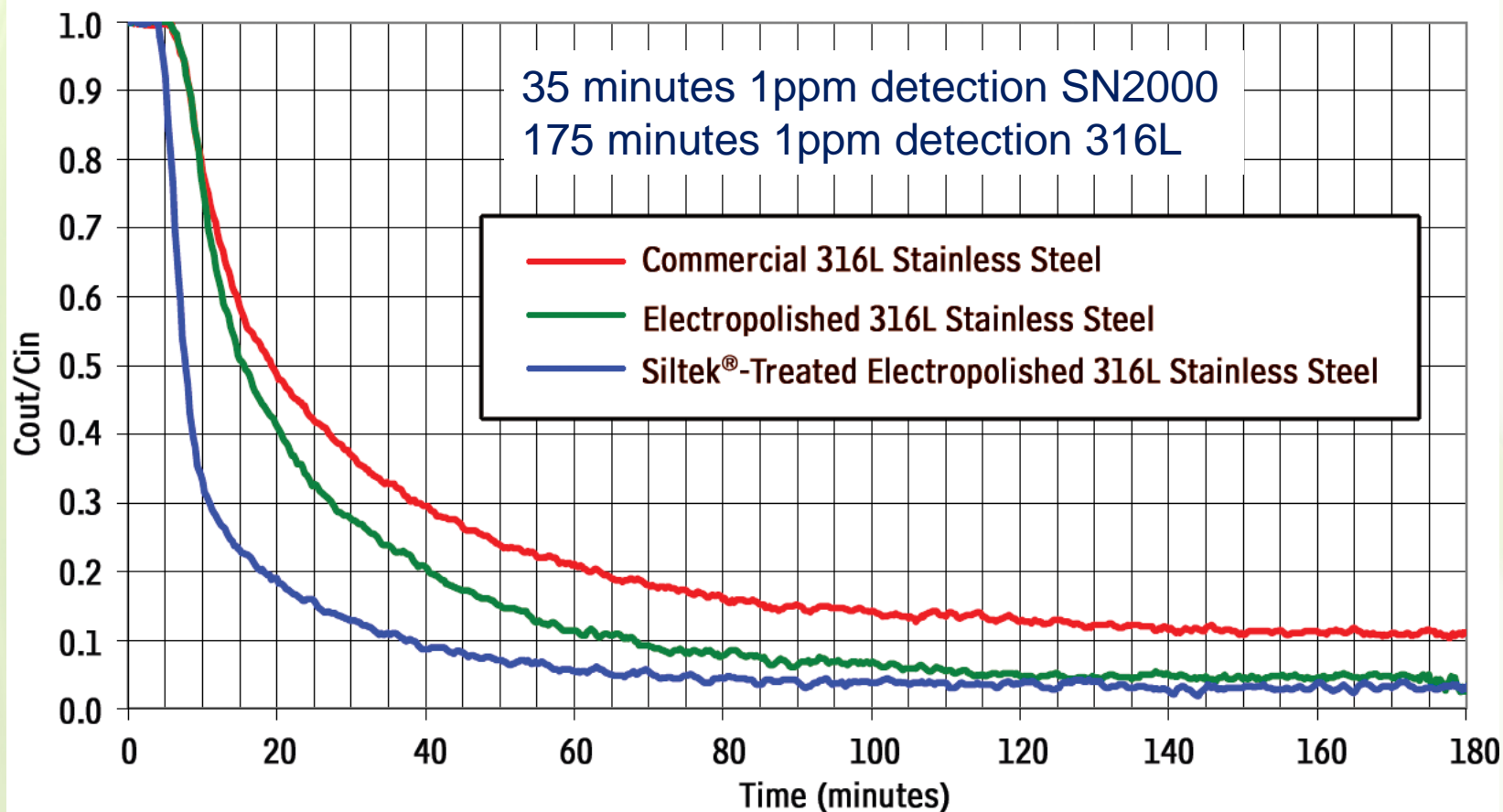
- **Low reactivity with wide range of chemicals**
  - Sulfurs, Ammonia, Mercury
- **Allows low level (ppm-to-ppb) contamination monitoring**
  - Petrochemical refining, Oil & Gas, LNG production/transfer, Emissions & Air monitoring
- **Quick recovery after process upsets**

**Functionalized silicon (SN2000) good to single-digit ppb detection levels!**

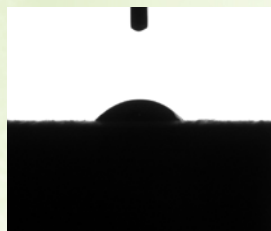
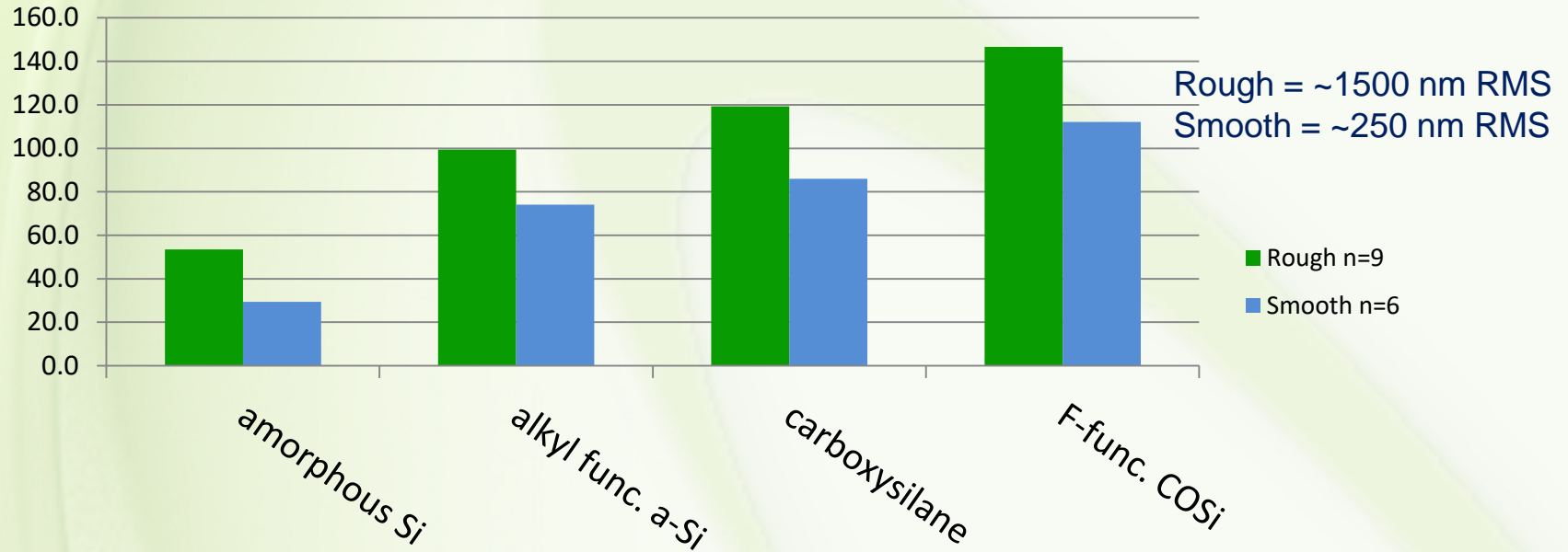
# “Wet-Up” Moisture Detection



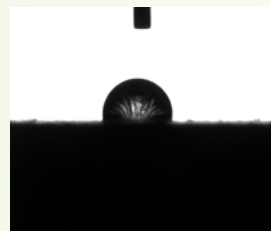
# “Dry-Down” Moisture Removal



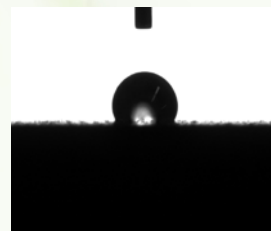
# Hydrophobicity Measurement



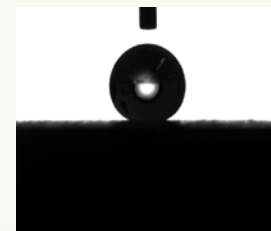
amorphous Si  
Silcolloy  
49°



alkyl func. a-Si  
SilcoNert  
101°



Carboxysilane  
Dursan  
121°

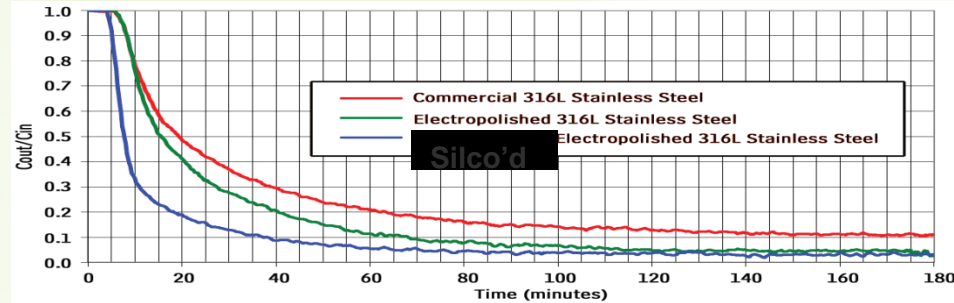


F- func.  
Notak™  
163°

# Decrease system pump down time

# SilcoGuard:

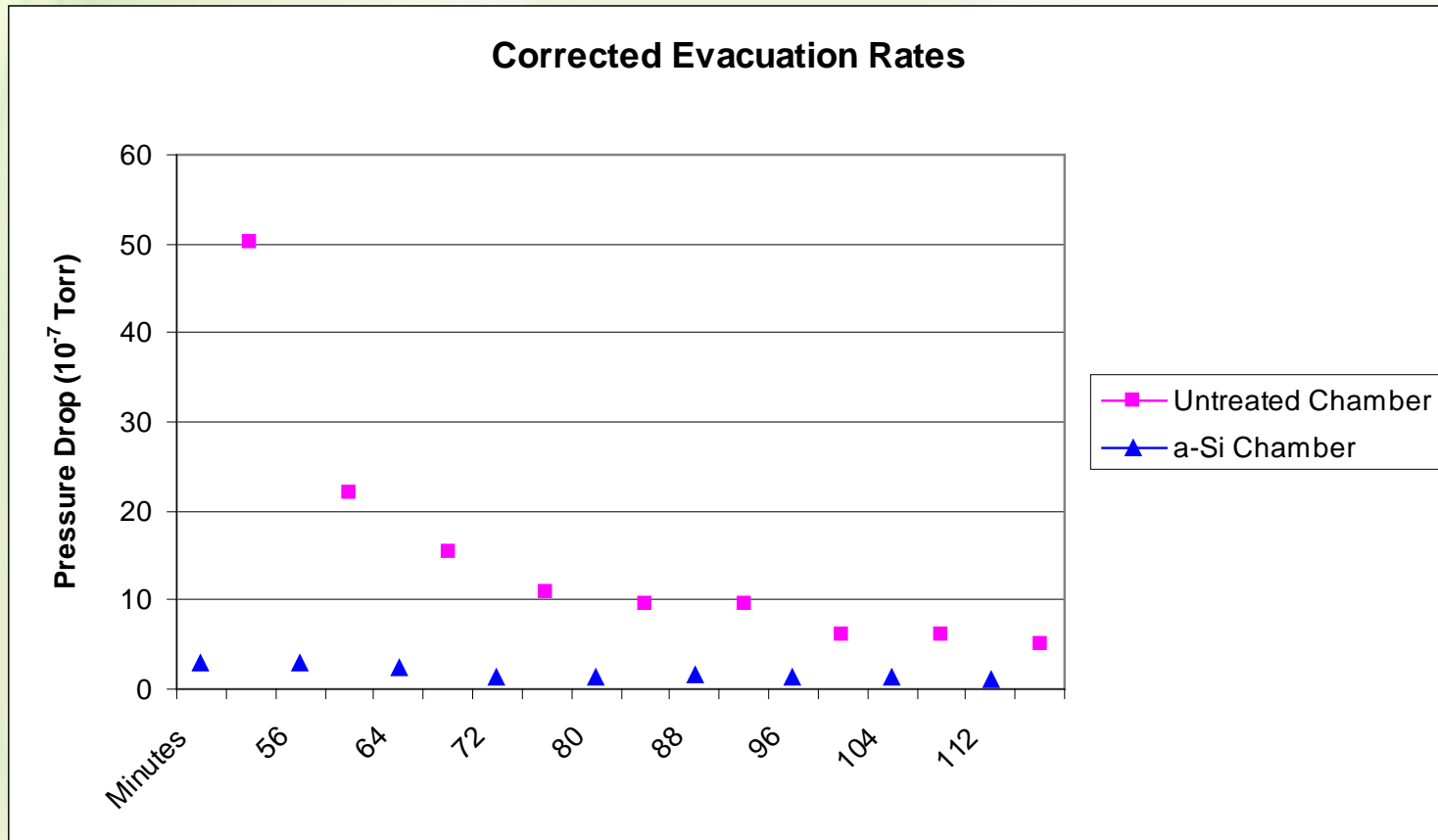
- Ultra-High-Vacuum (UHV) environments ( $1 \times 10^{-7}$  Torr or better)



- Materials outgas into the vacuum environment.
- Outgassing increases pressure in the chamber (directly related to dry down data)
- Requires large pumps and long “pump down” times
- SilcoGuard blocks materials from outgassing into the vacuum environment.



# Comparative Evacuation Rates



# SilcoGuard Advantages

- Consistently outperforms cleaned parts for ability to pump down faster: No need to clean
- Eliminates bake out of components as received from manufacturer
- Ability to achieve lower base pressure with smaller pumps
- Faster process cycle time vs. uncoated systems
- Superior high temperature stability up to 600° C

# Overall Coating Applications

- University/Research
  - Coating of accelerator chambers to create higher vacuum environment
- Semiconductor
  - Use in coating of semi-conductor manufacturing equipment to decrease defect rate
- Analytical
  - Reduce time needed to achieve high vacuum environments in analytical equipment (SEM, XPS, etc.,.)
- Bio/pharma
  - Improve surface properties of probes, tips, dies, metal tubing, analytical instrumentation, tools, and more

# Conclusion

- Coatings are available for a wide range of applications
- Optimize based on desired property
  - Inertness
  - Corrosion Resistance
  - Anti-Fouling
  - Purity
- Ultimate benefit is superior performance
  - Analytical results
  - Extend life
  - Reduce labor and capital cost
  - Improve efficiency
  - Optimize material selection and cost performance



# Contact Us

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