Traitements superficiels S3P de dernière génération pour les aciers et alliages inoxydables

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SURF – THERM
« Nouveautés techniques en micromécanique horlogère et leurs caractérisations »
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Corrosion –
A problem as old as mankind

Typically used for …

- Medical industry
- Food and beverages processing
- Pumps and valves
- Fastening solutions
- Automotive industry
- Consumer products
- Chemical Industry
- Oil & gas Industry

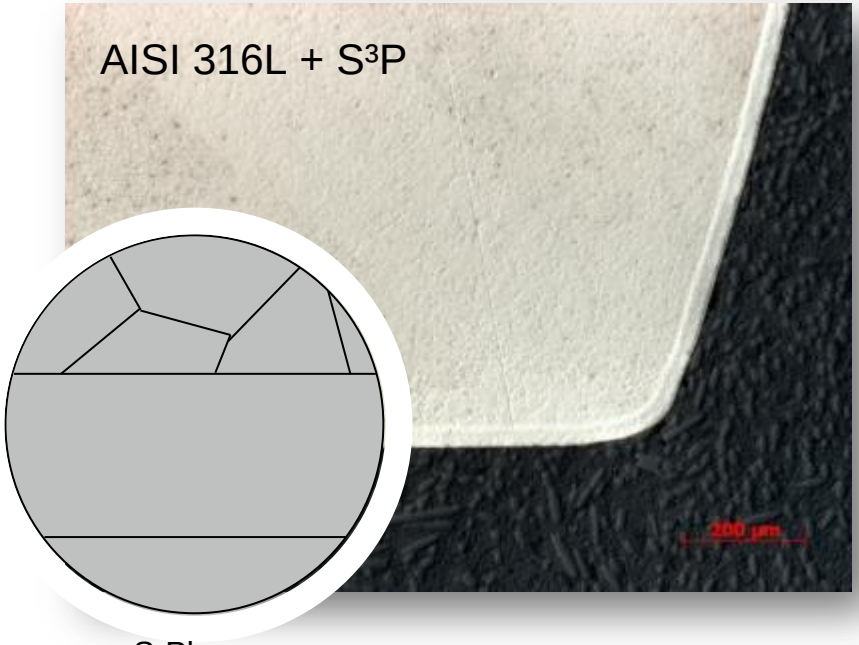
Different, but not visually

untreated + S³P

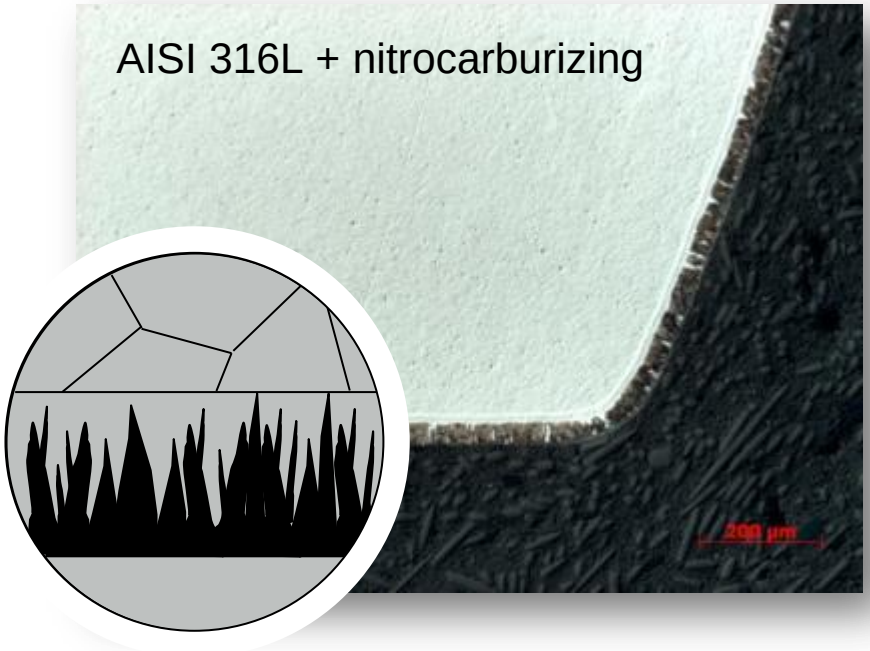
The optical appearance of stainless steel is still metallic blank, but the mechanical properties are massively improved by S³P

Standard processes do not apply

Conventional hardening processes like carburizing, nitriding or nitrocarburizing deteriorate the corrosion resistance .
High temperatures lead to precipitation of chromium nitrides and carbides .

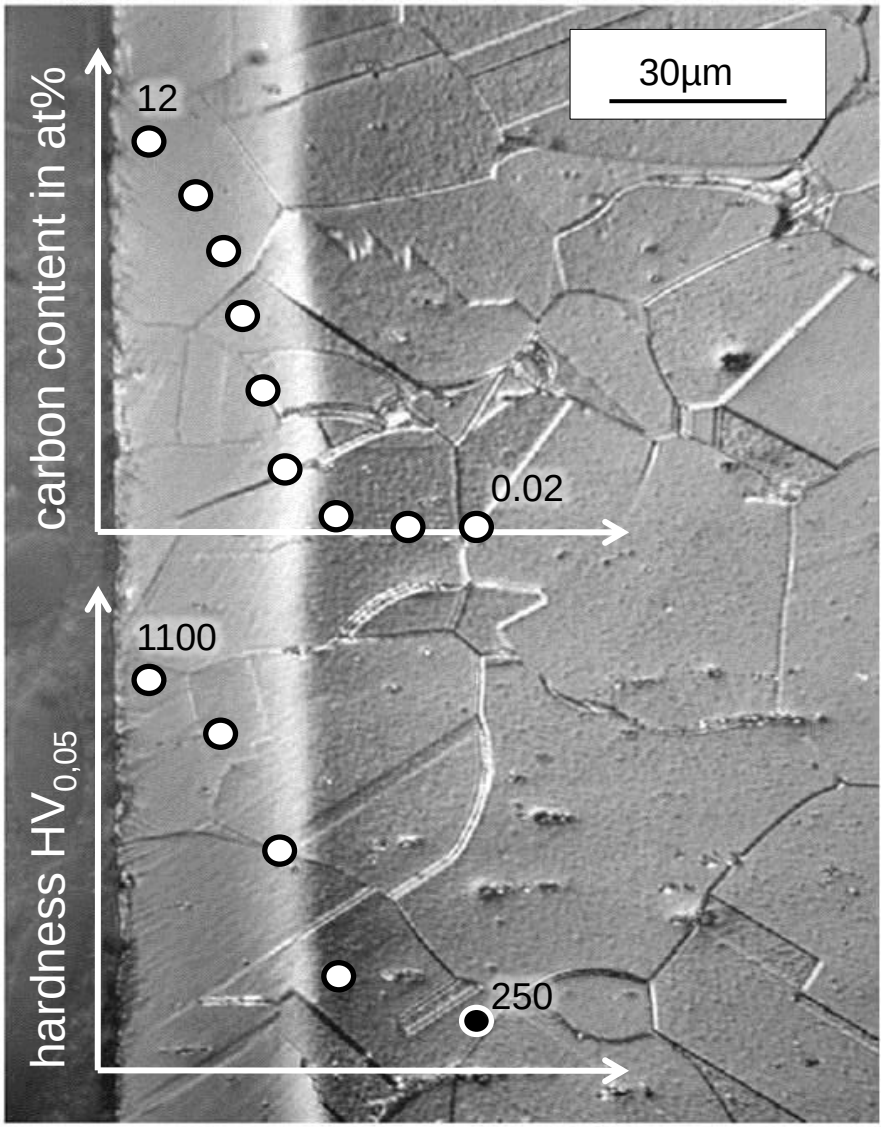


S-Phase
Expanded austenite
without precipitations



Nitrides and Carbides on
the surface followed by
a diffusion zone

S³P offers the solution



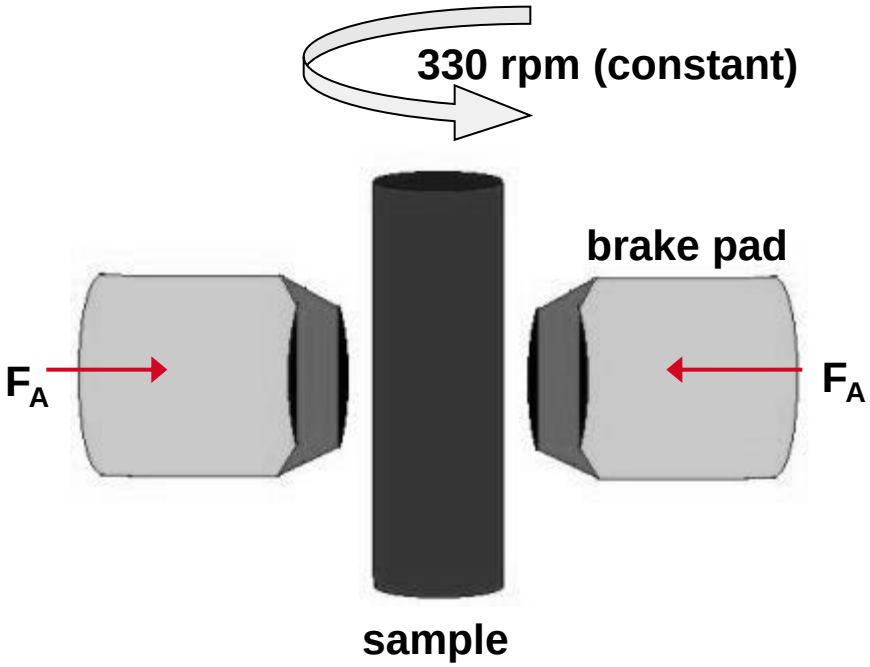
- Supersaturation of Carbon/Nitrogen
- Gradual hardness increase
- Low temperature diffusion process
- Proprietary process
- Outstanding mechanical properties

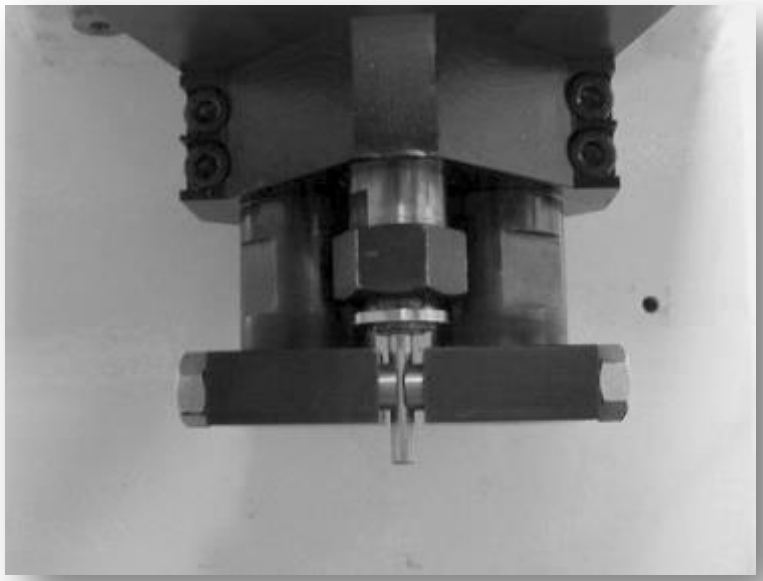
Achieving mechanical durability

untreated	Resistance to …	S³P-treated
+	Corrosion	+
–	Wear	+
–	Galling	+
–	Fatigue	+
–	Cavitation	+

Galling - Fretting

One of the major problems of stainless steel





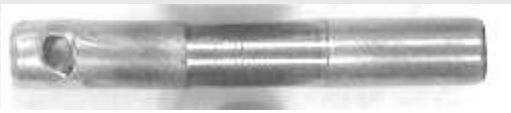
Laboratoire de Tribologie et Dynamique des Systèmes de l'Ecole Centrale de Lyon

Galling - Fretting

Without surface treatment

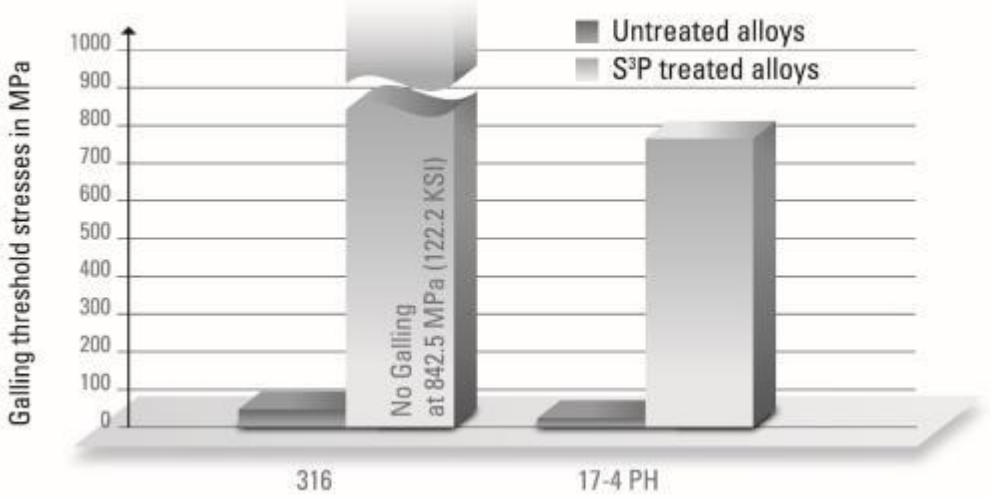
With S³P

Time to failure: AISI 316L - untreated	Time to failure: AISI 316L – S³P K33
~ 1.5 s	**~ 60 s**



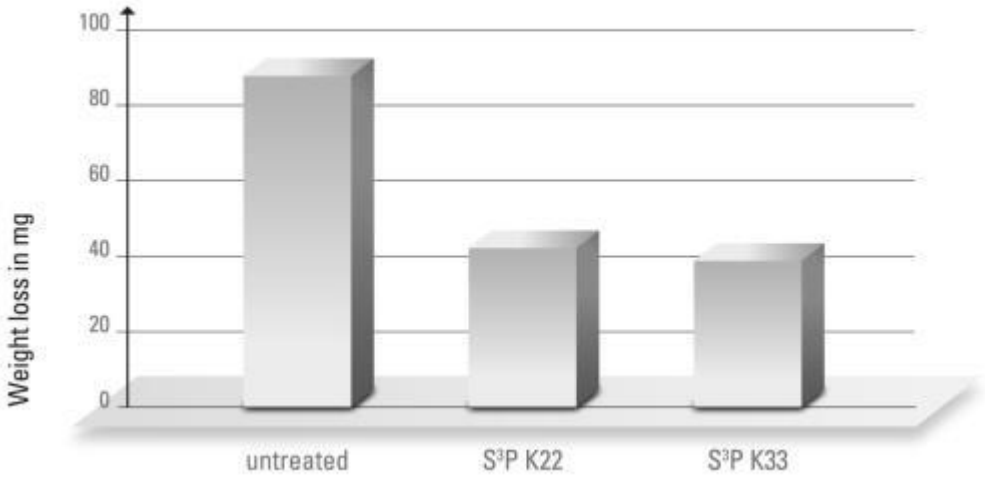
Galling - Fretting

- Galling test according to ASTM G98
- Stainless steel AISI 316L
- Unlubricated
- Ground surface finish
- Galling threshold stress rises from 6 KSI to 120 KSI



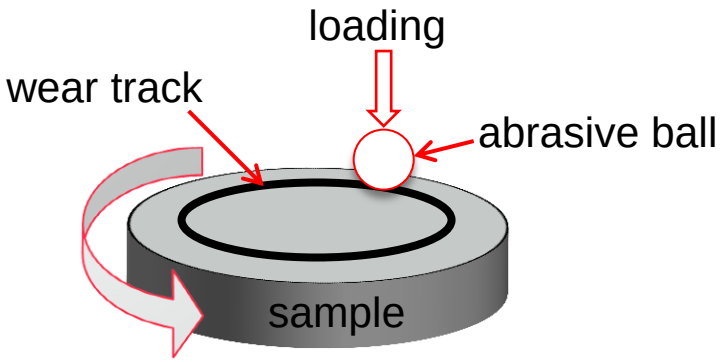
Abrasive Wear Resistance

- Taber Abraser 5131
- Force: 500gf/wheel
- 500 Cycles
- Material: 316L (1.4404)



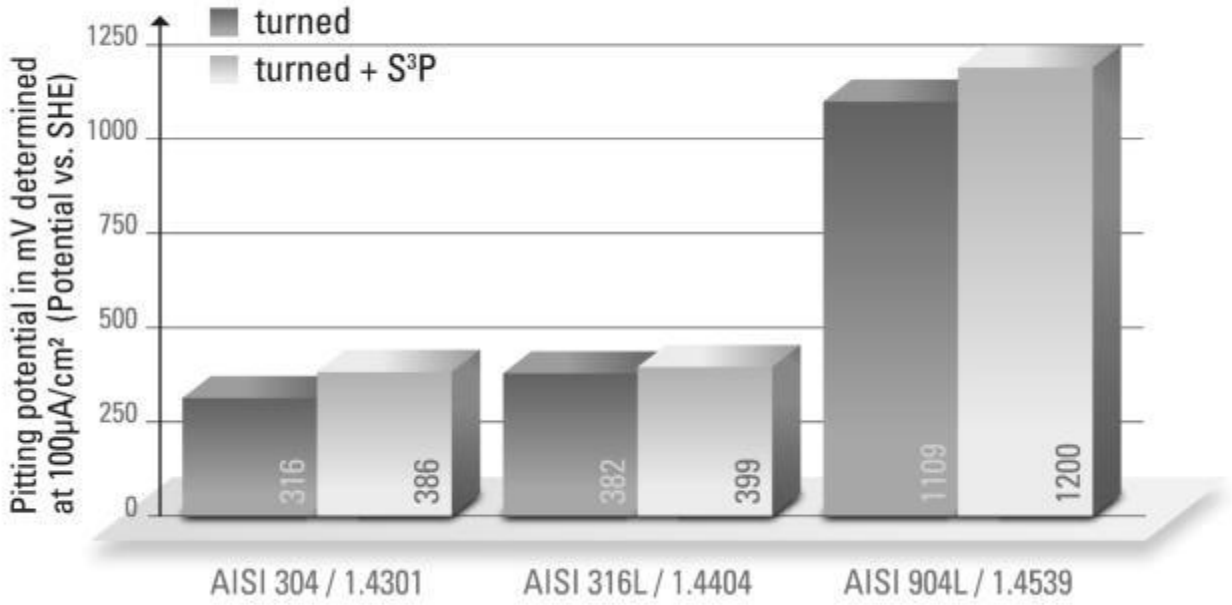
Wear resistance: Ball on disk

- Loading: 10 N
- Rotation: 100 rpm at speed 50 mm/s
- Ball material: Al_2O_3 (Radius 5 mm)
- Wear depth measured after 500 m



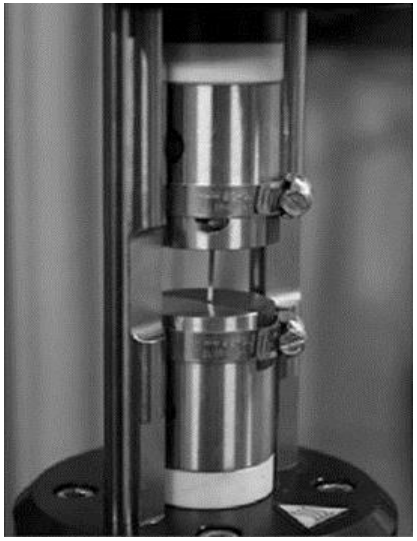
Wear depth	untreated	S³P
AISI 420 (1.4034)	15 µm	7 µm
Inconel 625 (2.4856)	82 µm	3 µm

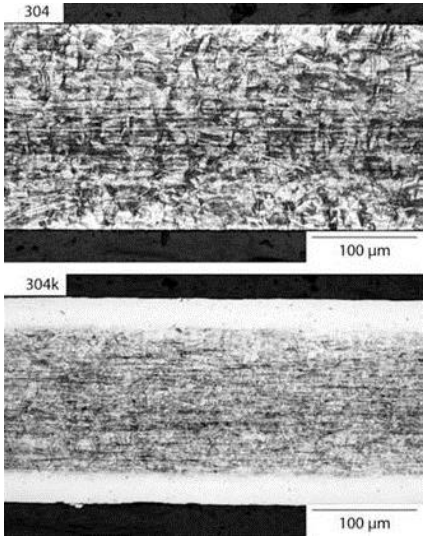
Excellent corrosion resistance maintained



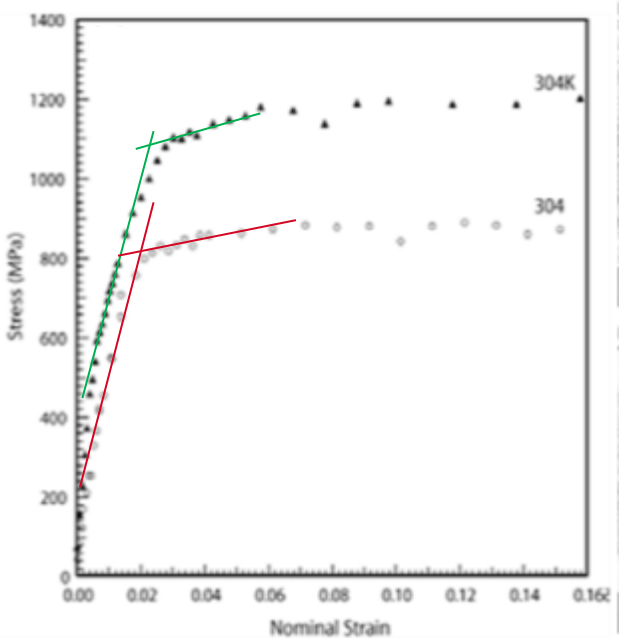
High Strength of S-Phase

- S-Phase has higher strength than base material
  - Geometrical fraction of S-Phase is typically marginal
  - Thus the influence of S-Phase on mechanical strength of a part is typically marginal
  - High strength of S-Phase can be shown on thin walled parts (e.g. thin sheet or foils)



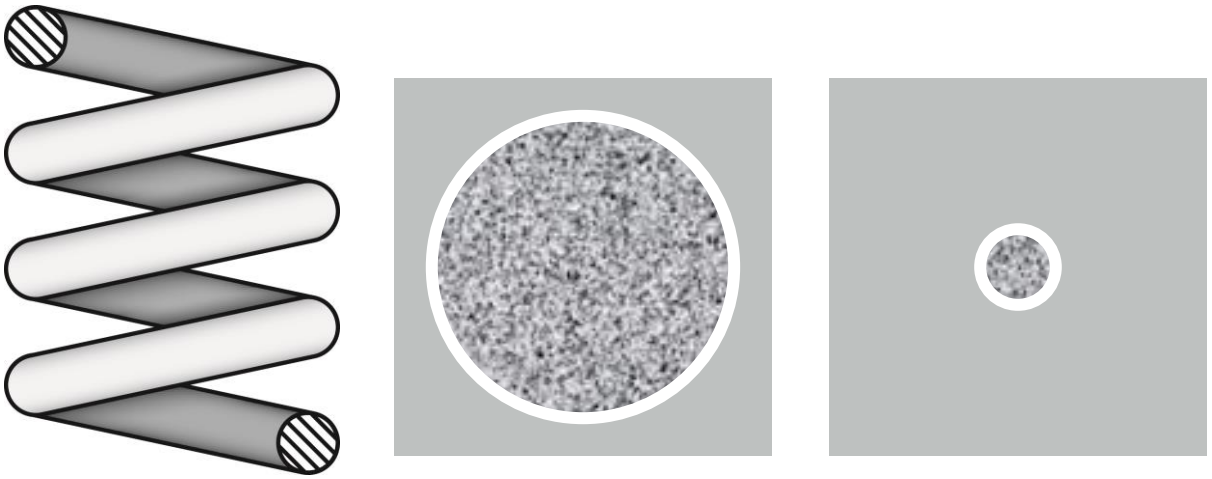


Source: Jones et al. (2010)



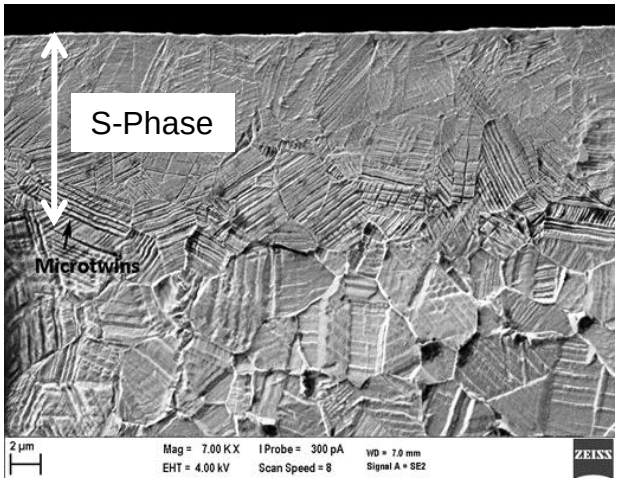
Example: Stainless Steel Springs

- Improved stress corrosion resistance
- Increased fatigue strength
- Higher spring factor (esp. for small springs)



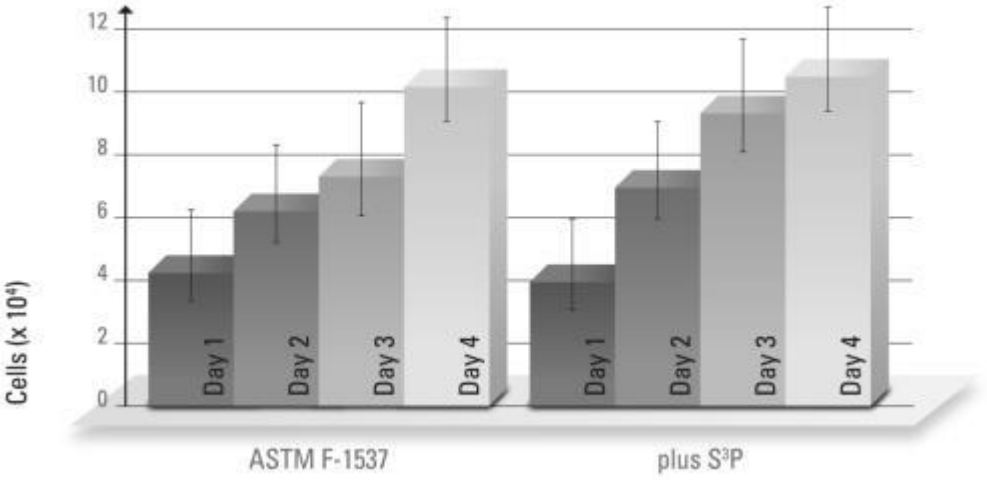
Biocompatibility

- Major medical companies work together with S³P (e.g. implants, medical tools, …)
- Both stainless steel and CoCrMo-alloys remain biocompatible



CoCrMo alloy F-1537

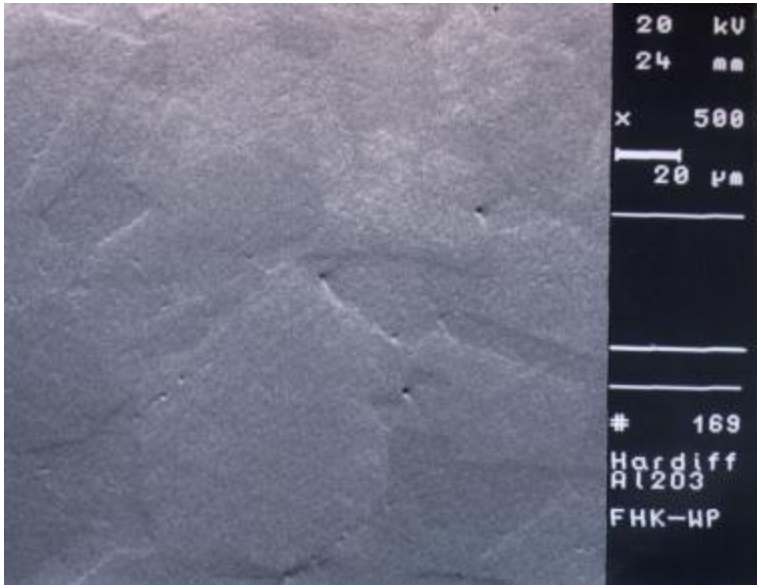
hFOB 1.14 human foetal osteoblast cell line



M. Caligari Conti et al., Biomatter 4, e27713 (2014)

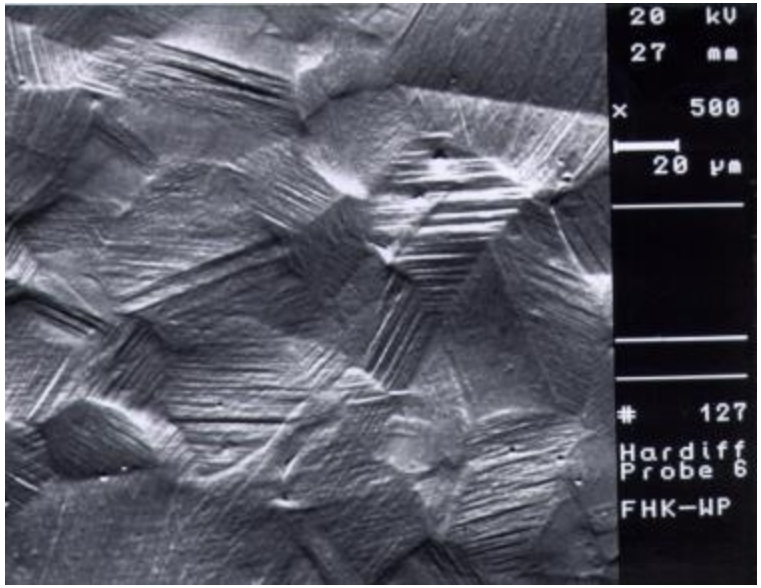
Surface roughness and morphology

Examples	Ra value before S³P in µm	Ra value after S³P in µm
lapped surface	0.04 – 0.05	0.06 – 0.08
machined surface	0.22 – 0.25	0.21 – 0.26



AISI316L + polished

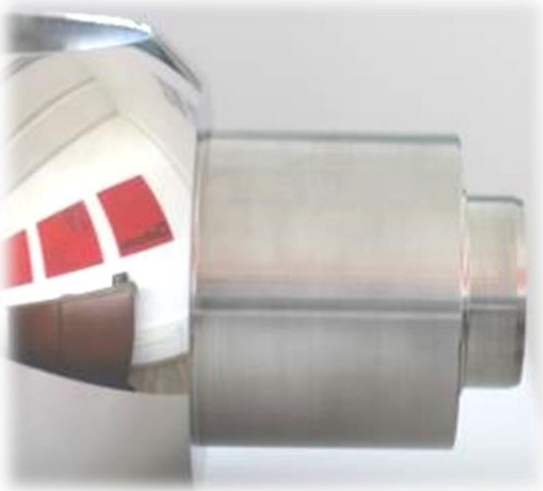
Ra value: ± 0,04 µm



AISI316L + polished + S³P

Ra value: ± 0,08 µm

Optical appearance



- Geometry of finished parts is not changed
- Tight tolerances possible
- Metallic blank stainless steel surface

High Ductility of Carbon S-Phase

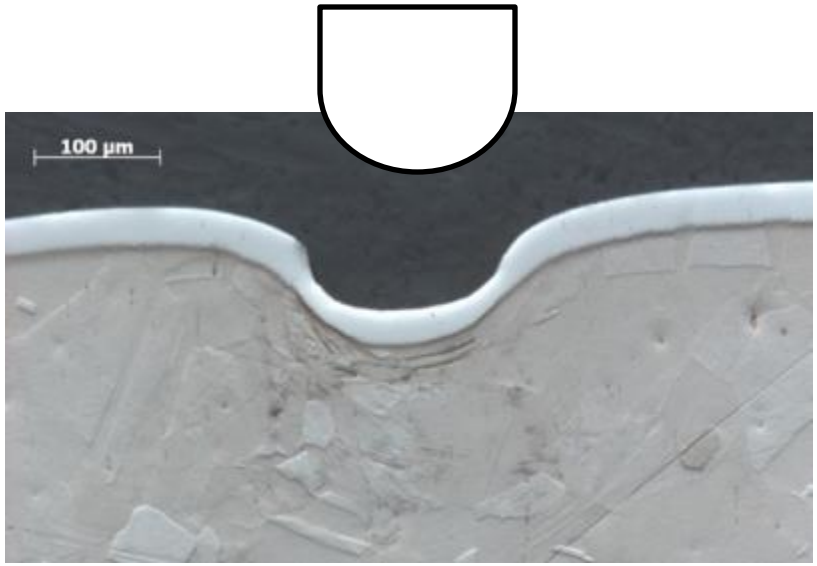
Hammer and Nail test – Rapid loading

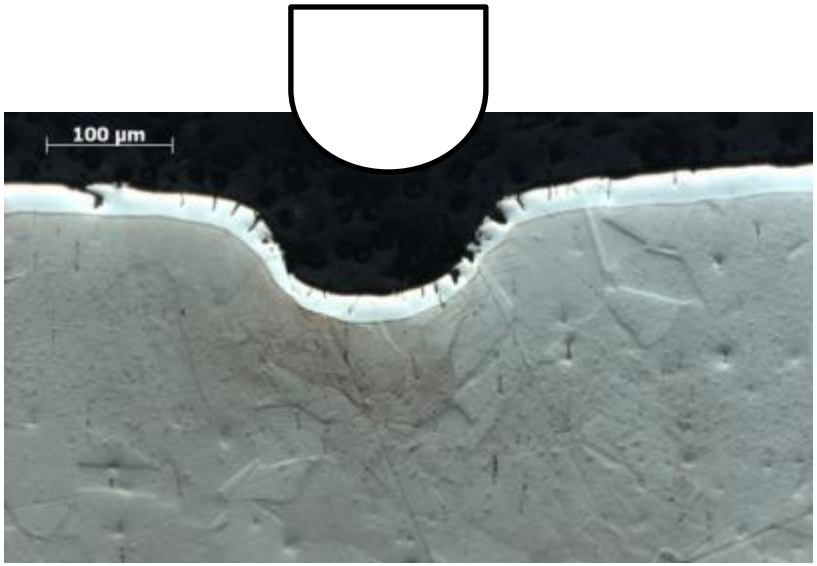
Material: 316L

Etchant: Beraha II

Left: Bodycote S³P, Carbon S-Phase

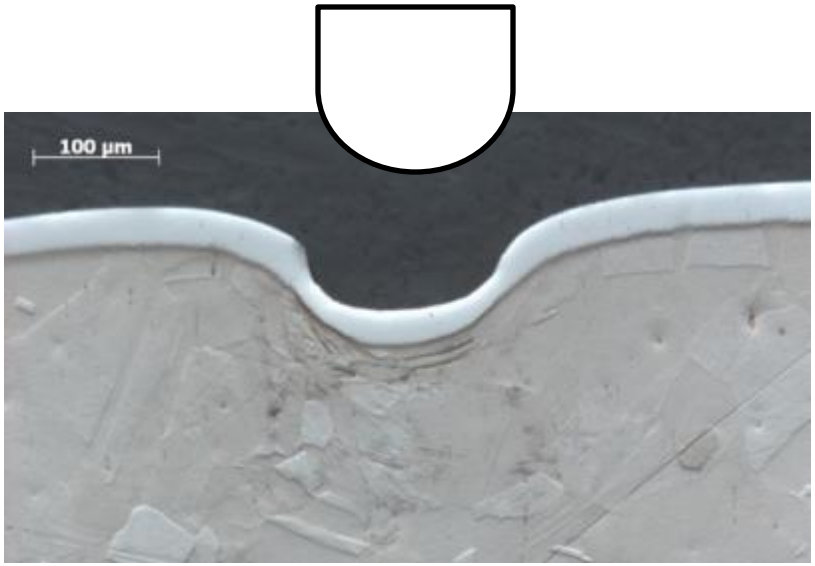
Right: Competitor, Nitrogen+Carbon S-Phase



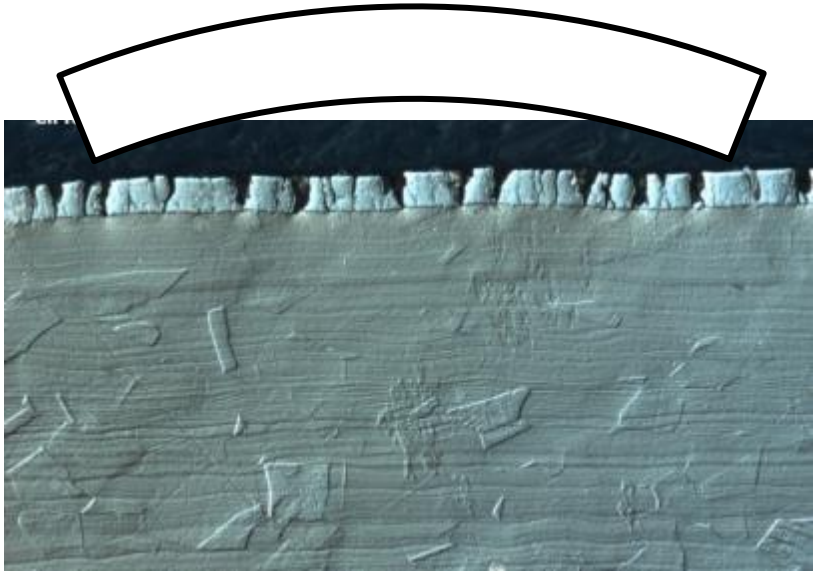


High Ductility of Carbon S-Phase

- Hammer and Nail test
- Rapid loading
- 316L
- S³P
- very ductile Carbon S-Phase

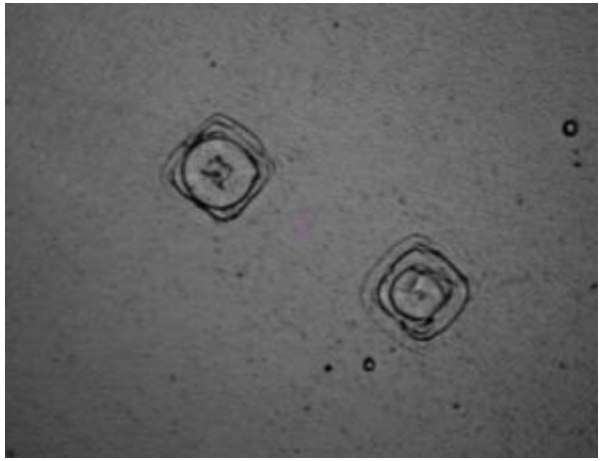


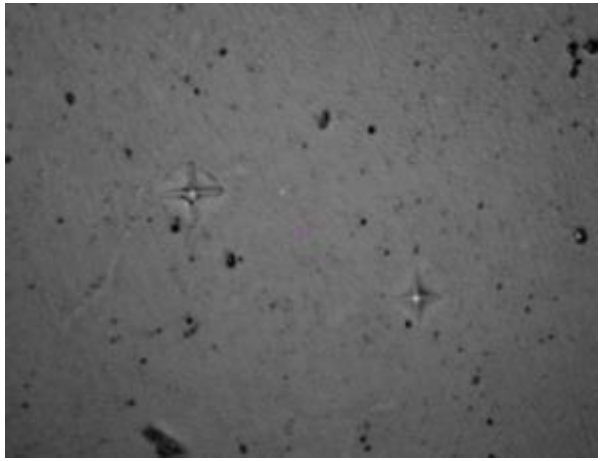
- Bending
- Slow loading (bending)
- 316L
- Electroless Nickel
- Brittle behavior with cracks



S³P as support for hard coatings

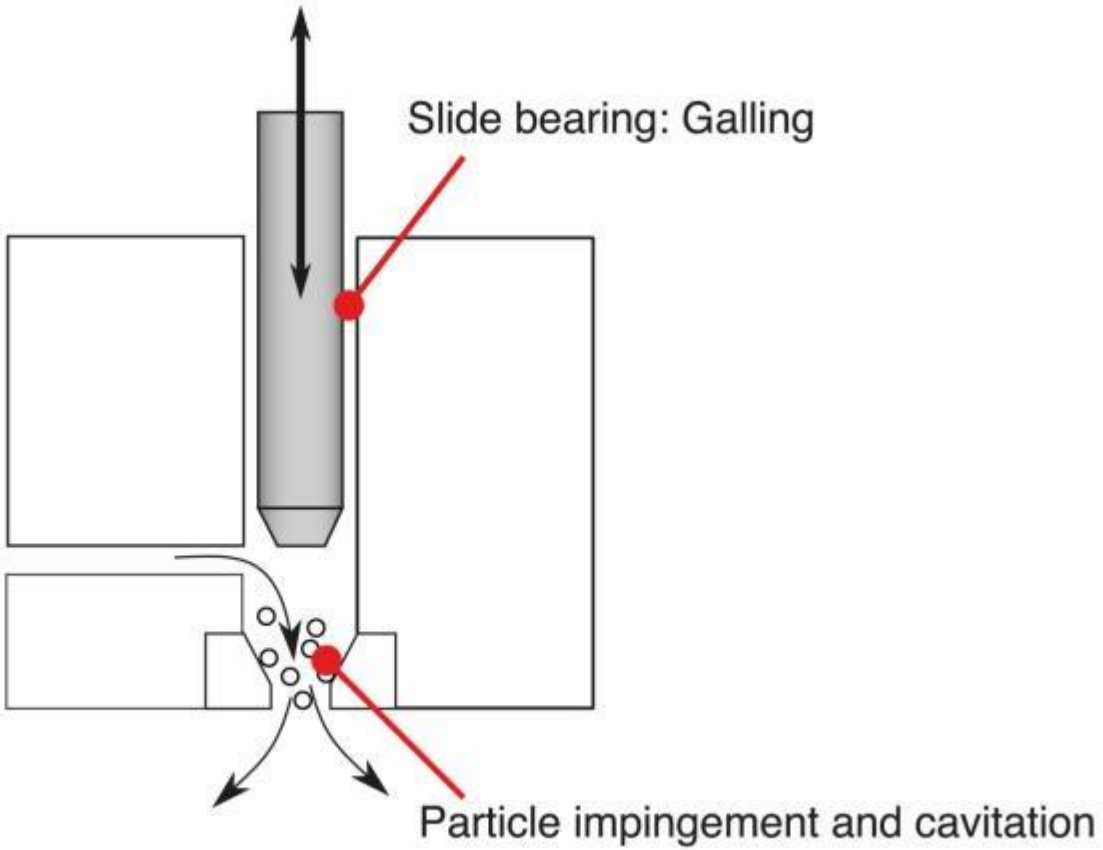
- S³P provides a corrosion resistant and ductile diffusion zone with surface hardness around 1000HV microhardness
- Hard coatings (PVD, DLC) are brittle and provide a surface hardness between 2000 and 4500HV
- Egg-shell effect is common risk for hard coatings
- S³P acts as a support structure reducing the risk of egg-shell effect



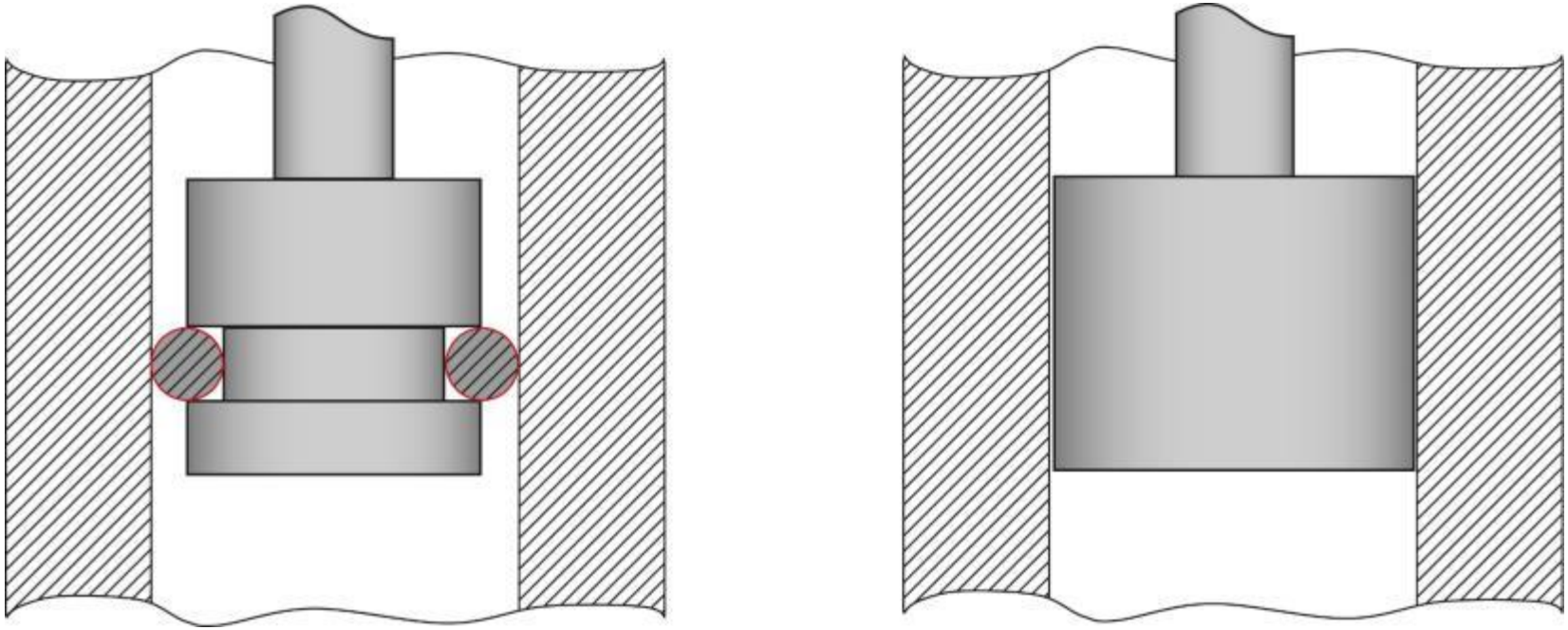


- HV0.05 indentations at 1000x magnification; left: DLC; right: S³P + DLC

Example: High pressure applications

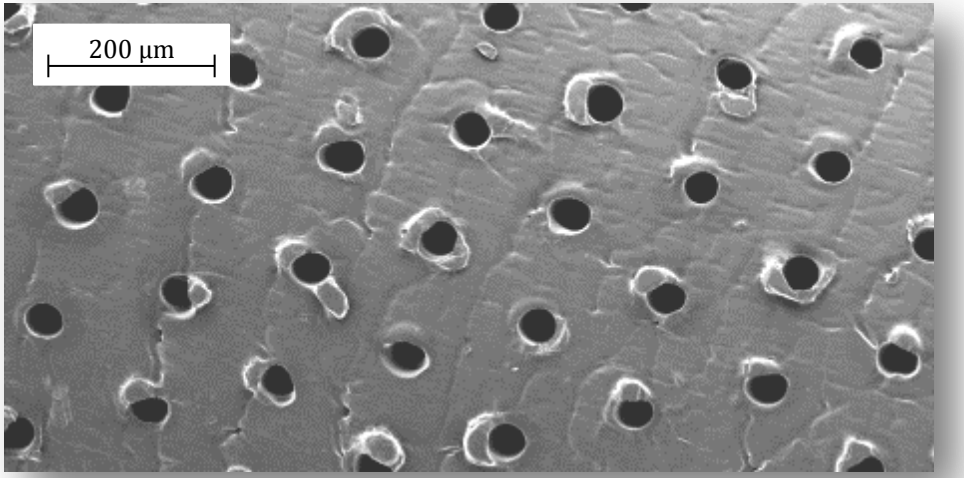


New design is possible: Slide Bearing



- Dosing pumps for food and pharmaceuticals
- Piston/ bearing for automotive industry

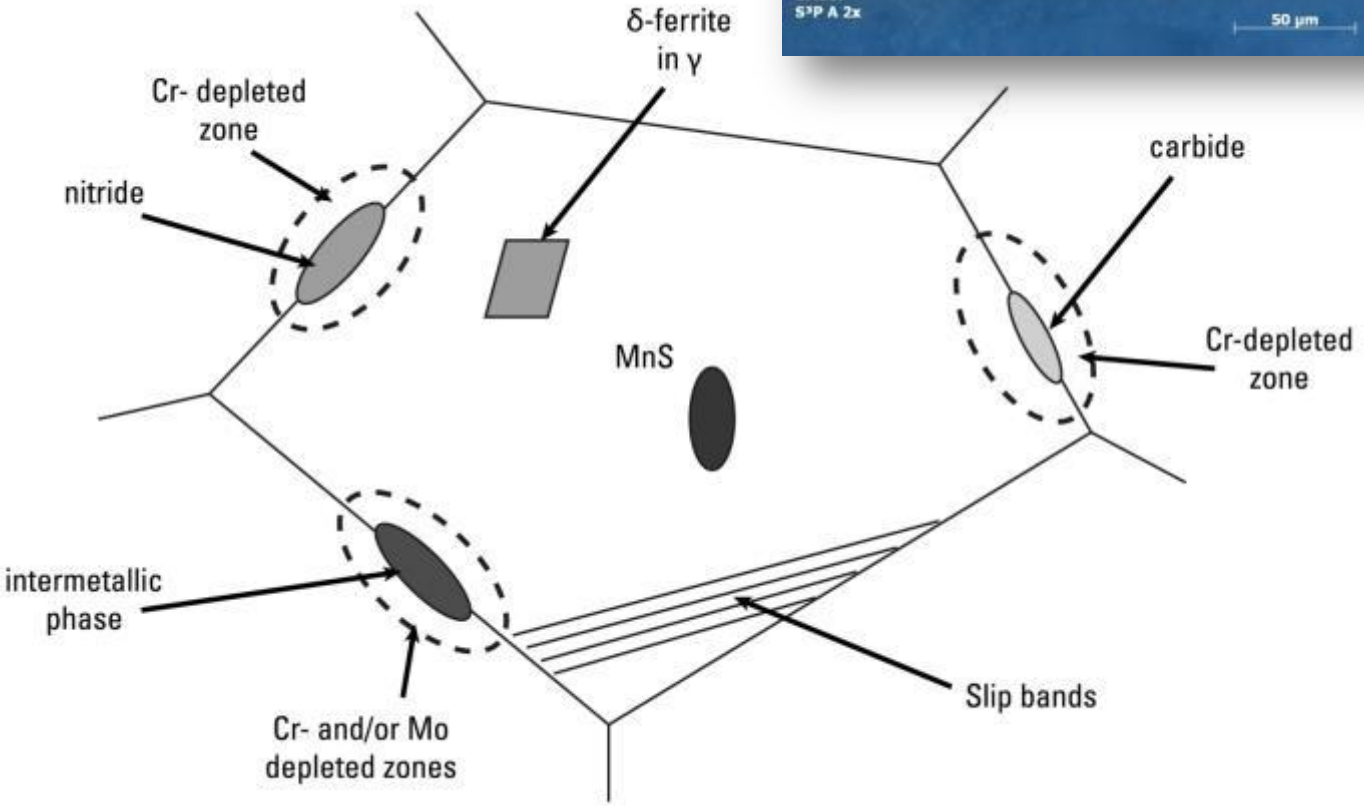
Even smallest spacing is treated



Jigging, Fixtures

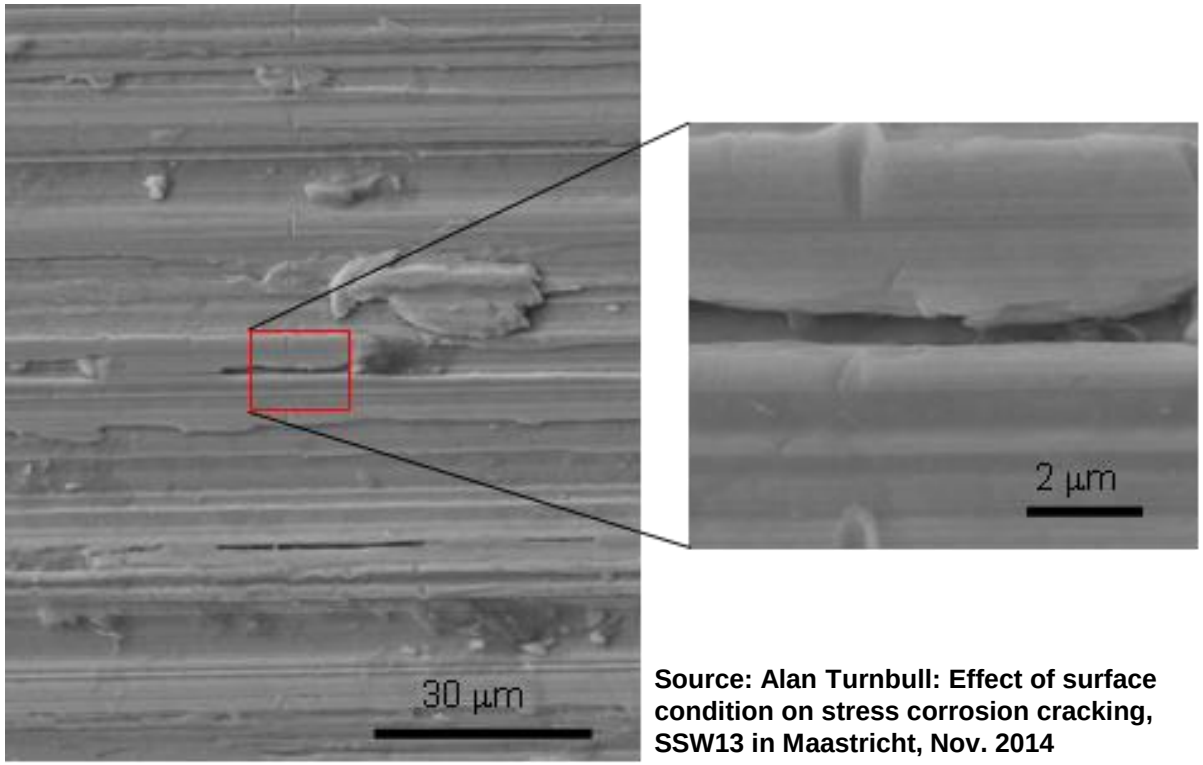
- Treatment of bulk material is no problem (point and line contacts allowed)
- Highly sensitive surfaces: use of special fixtures by S³P
- Large and heavy components up to Ø1.2 x 2m and 4t

Influences on Corrosion Resistance



Influence of Surface Finish

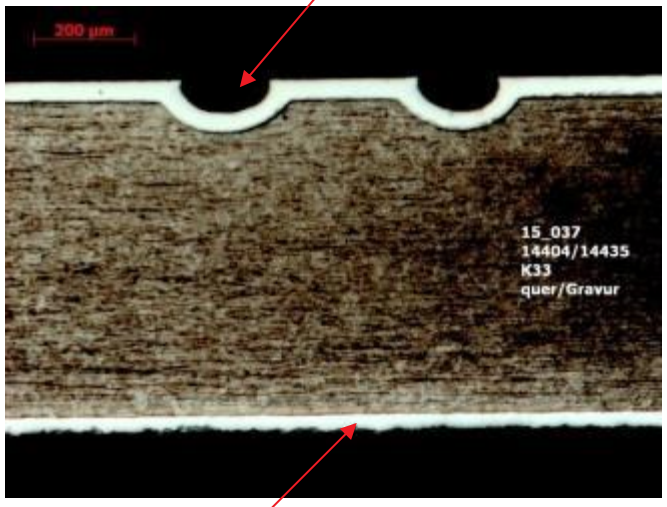
Example of surface defect on 304 SS formed by grinding, showing local deep grooving



Source: Alan Turnbull: Effect of surface condition on stress corrosion cracking, SSW13 in Maastricht, Nov. 2014

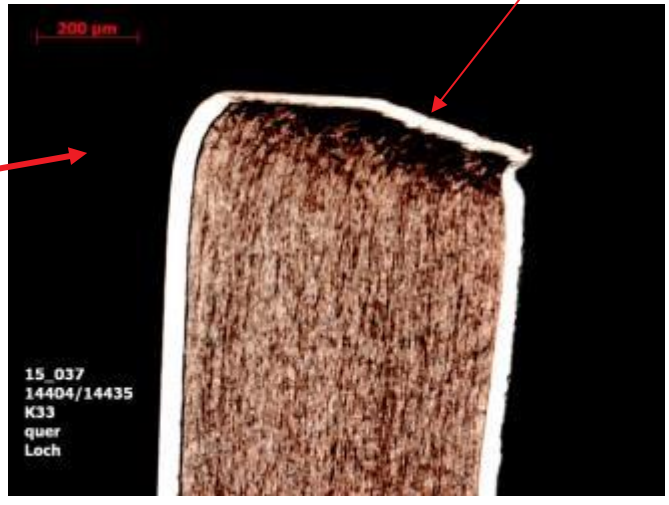
Watch Band Closure

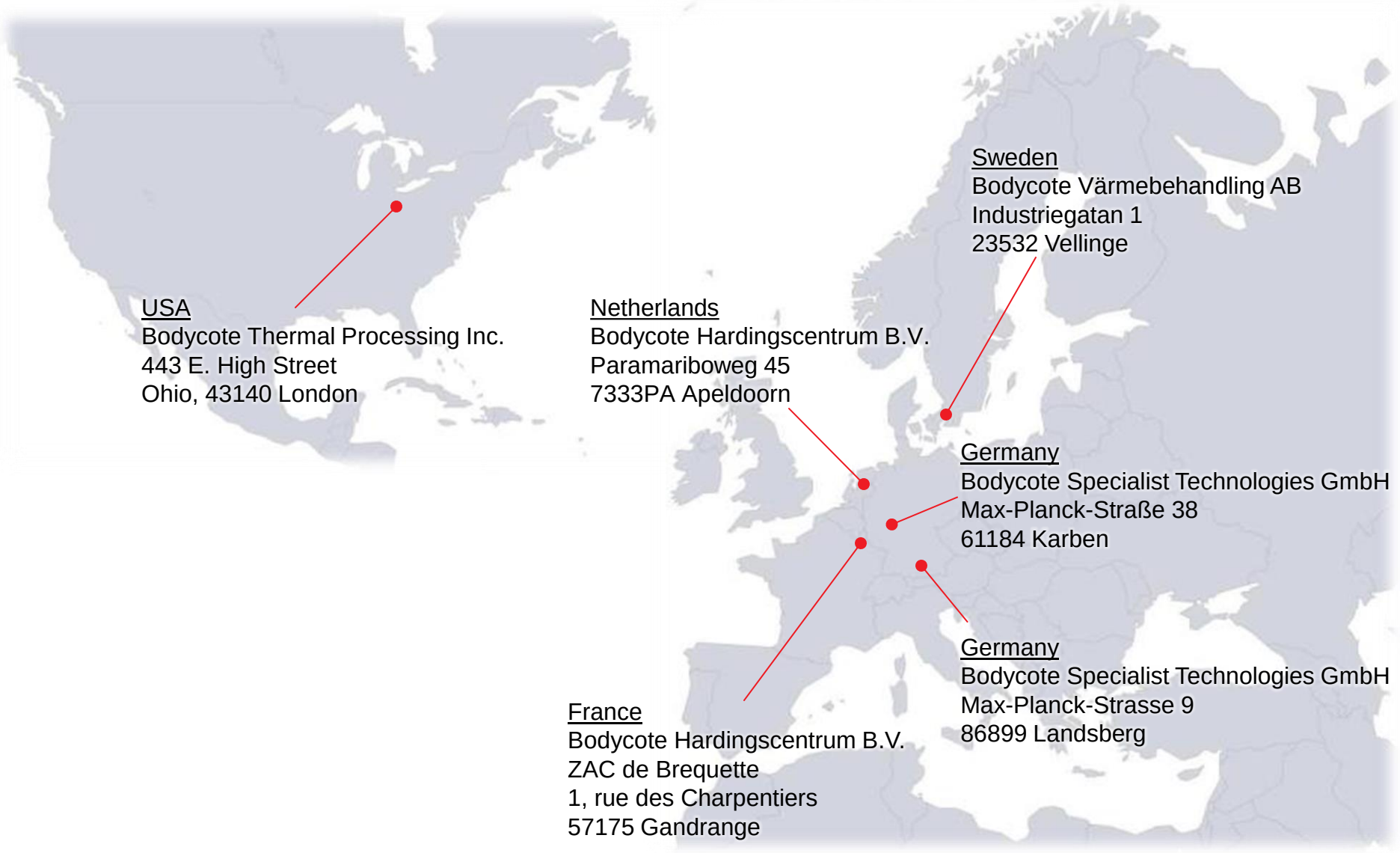
Engraving before hardening



ball-blasting after hardening

Fine blanking before hardening

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