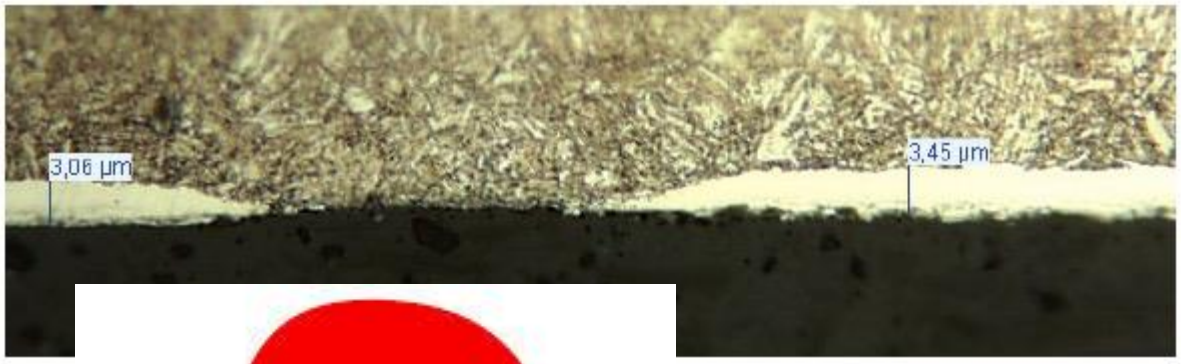
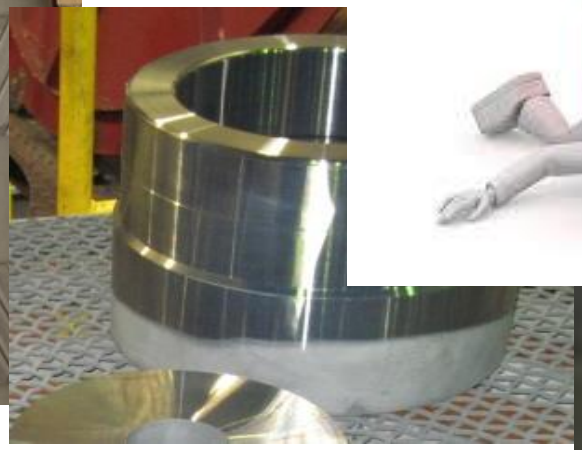
The influence of machining on the effects of nitriding

Pawel Szulc & Mikael Fällström
Bodycote AGI NEE

SHTE Västerås September 2015

Background





Machining - Nitriding

Bodycote

1. Background

Nitriding, surface reactions, surfaces, chemicals & machining

Mikael Fällström, Bodycote

2. Machining - Nitriding

- Raw Material, micro structure, hardness etc
- Surface control before nitriding processes
- Macro observations after nitriding processes
- Defects after machining
- Surface activations before nitriding processes

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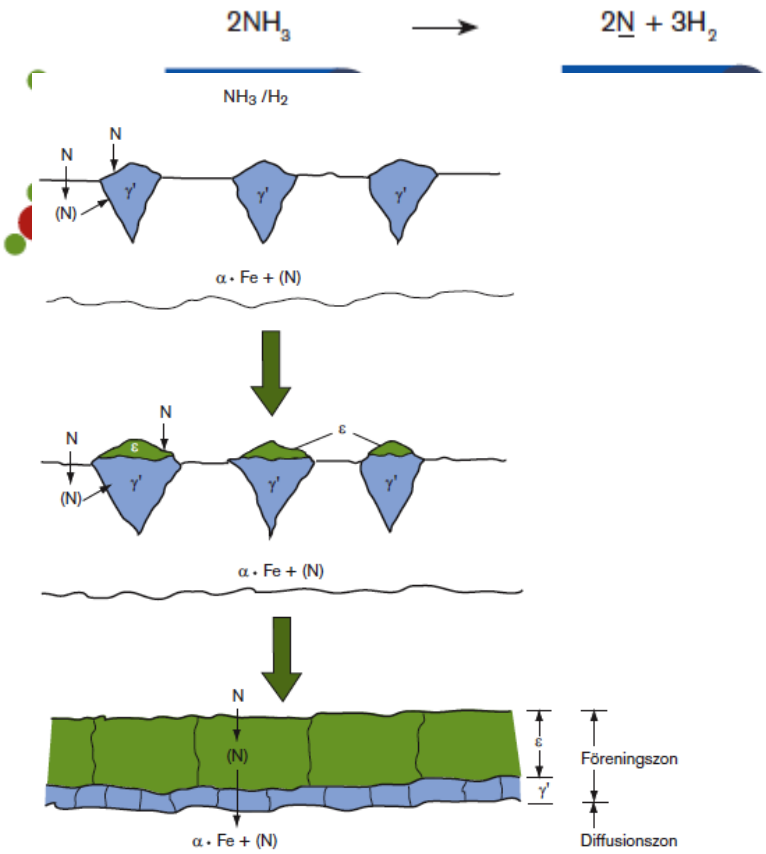
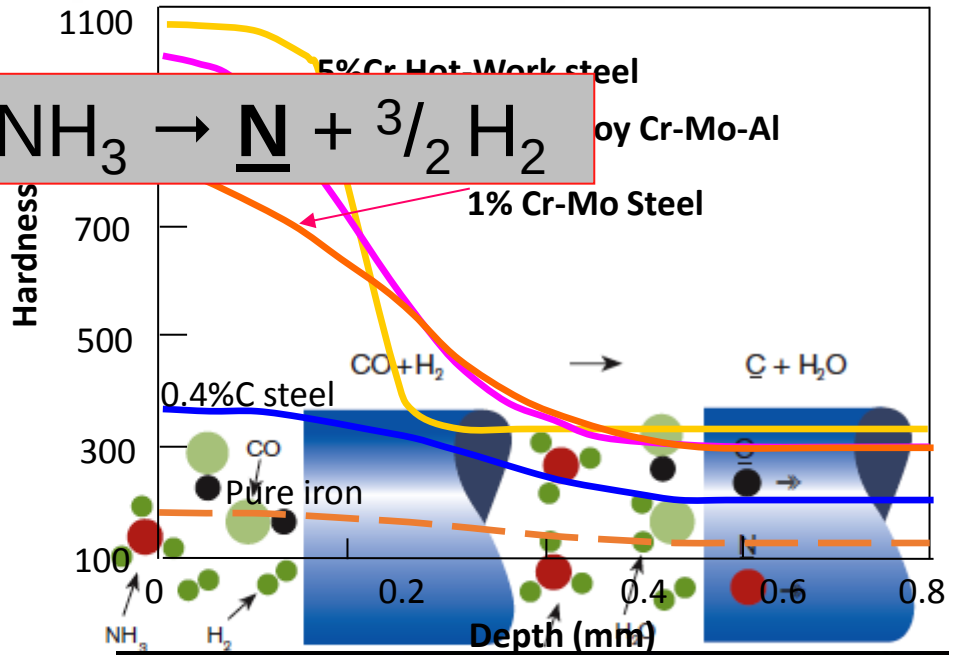
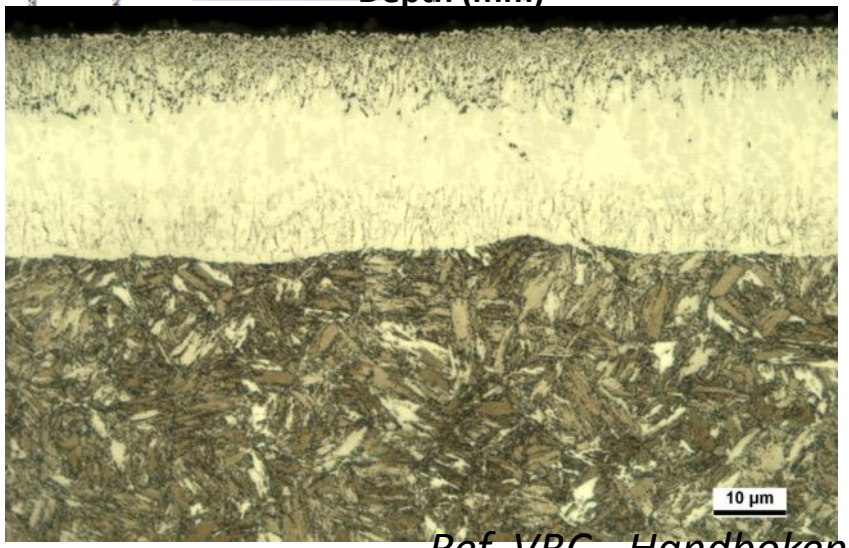
Background – Nitriding Processes

$$a_n = K \frac{p\,NH_3}{p\,H_2^{3/2}}$$

$$NH_3 \rightarrow \underline{N} + {}^3/_2\,H_2$$

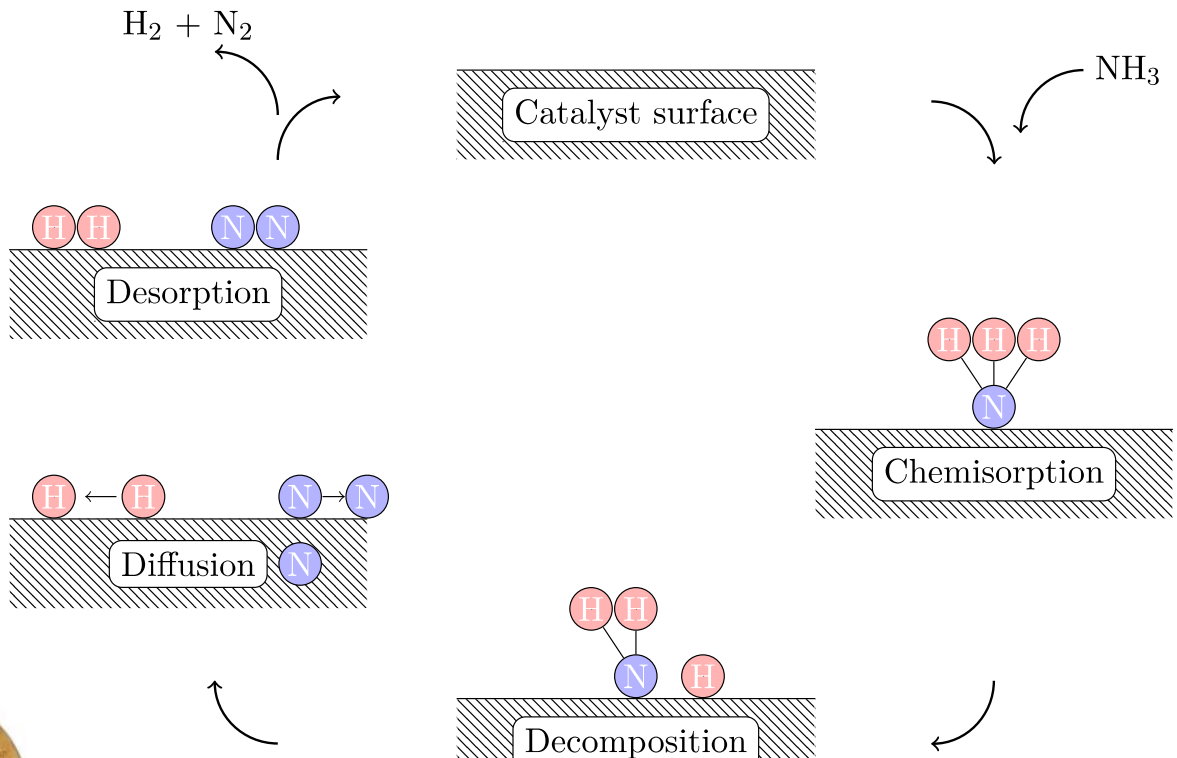




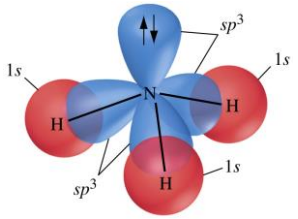


Ref. VBC - Handboken

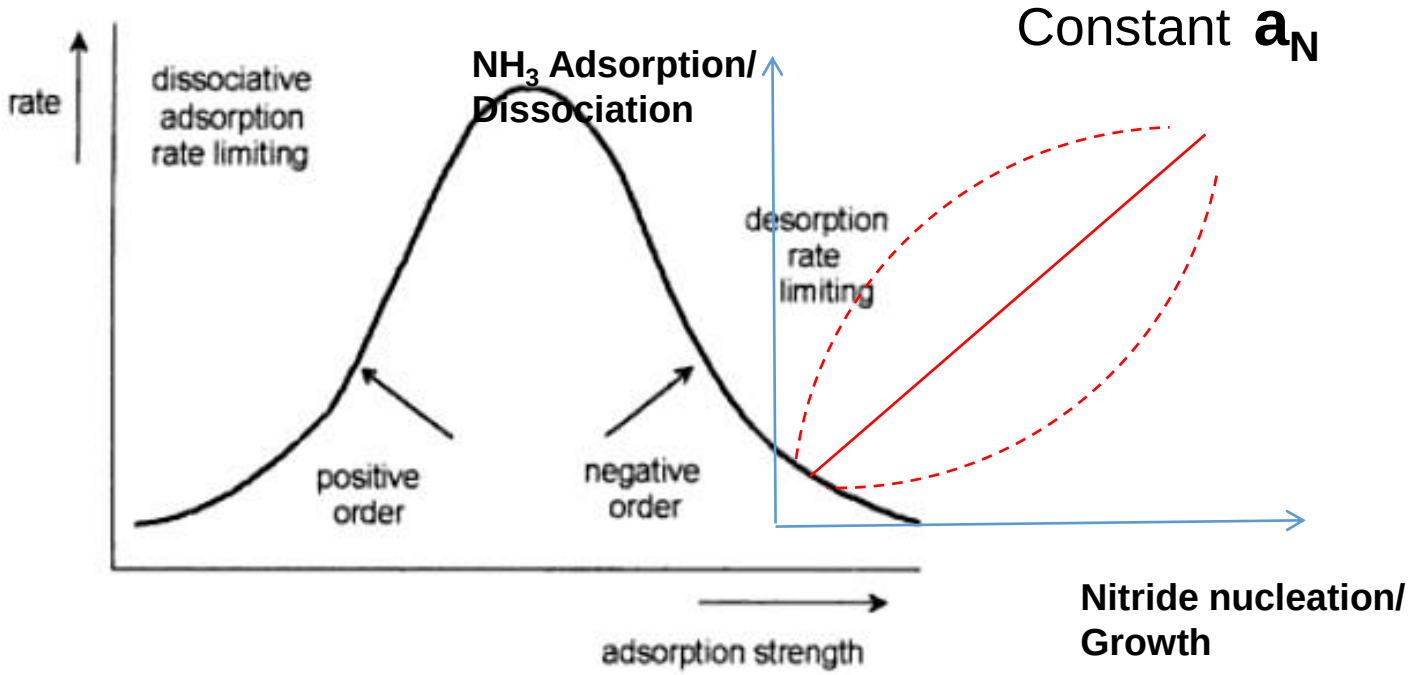
Background – Nitriding Processes



Gerhard Ertl 2007



Background – Nitriding Processes



Background – Surfaces

Contamination Layer >1µm
- Dirt
- Production residue

Adsorption Layer 1-10nm
- C and O, water

Reaction layer 1-10nm
- Oxides

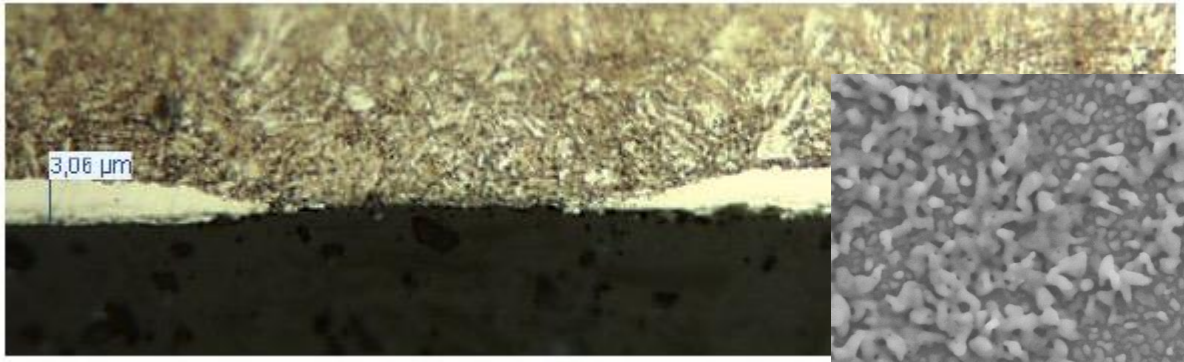
Deformed Boundary Layer >1µm

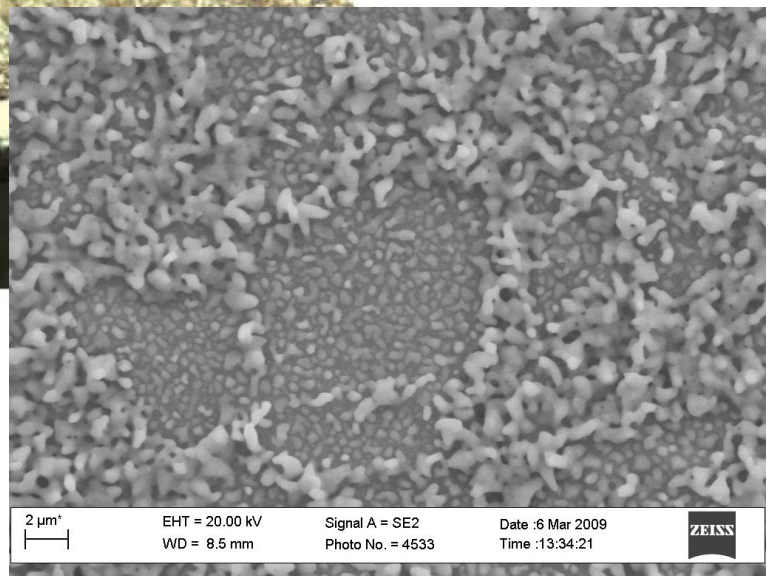
Base Material
- Hardness
- Microstructure
- Deformation

All processes before Nitriding will contribute.

Ref. Haase

Background – Surfaces





Passive Layers

Background – Surfaces

Chemical

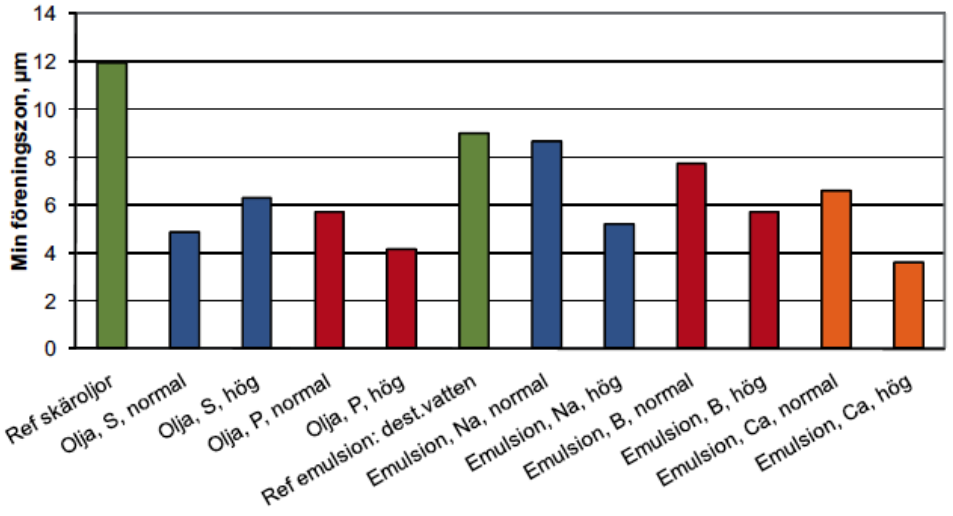
- Surface treatment : *Zinc Phosphate…*
- Washing: *Contamination Layer*
- Machining: *Reaction layers, Iron Sulfide*
- Raw Material*: Chemical composition*

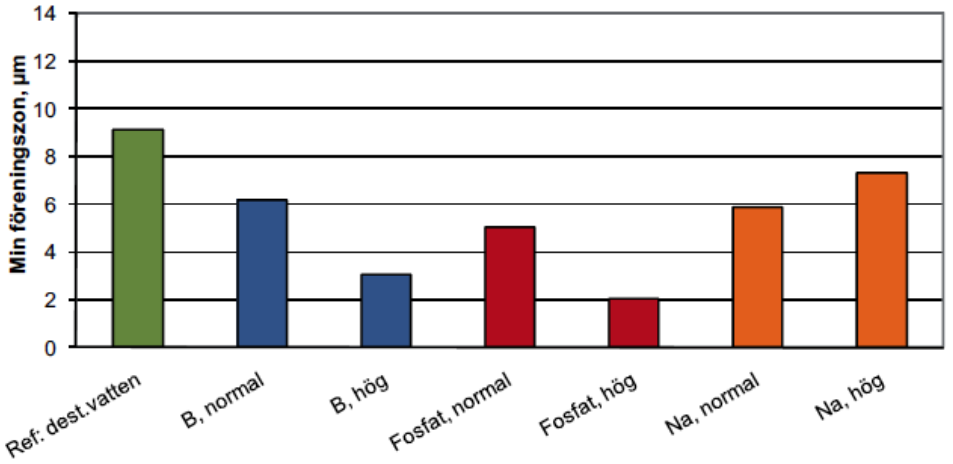
Mechanical

- Raw material: *micro structure*
- Machining: *plastic deformation*
- Machining: *Stresses*

Passive Layers

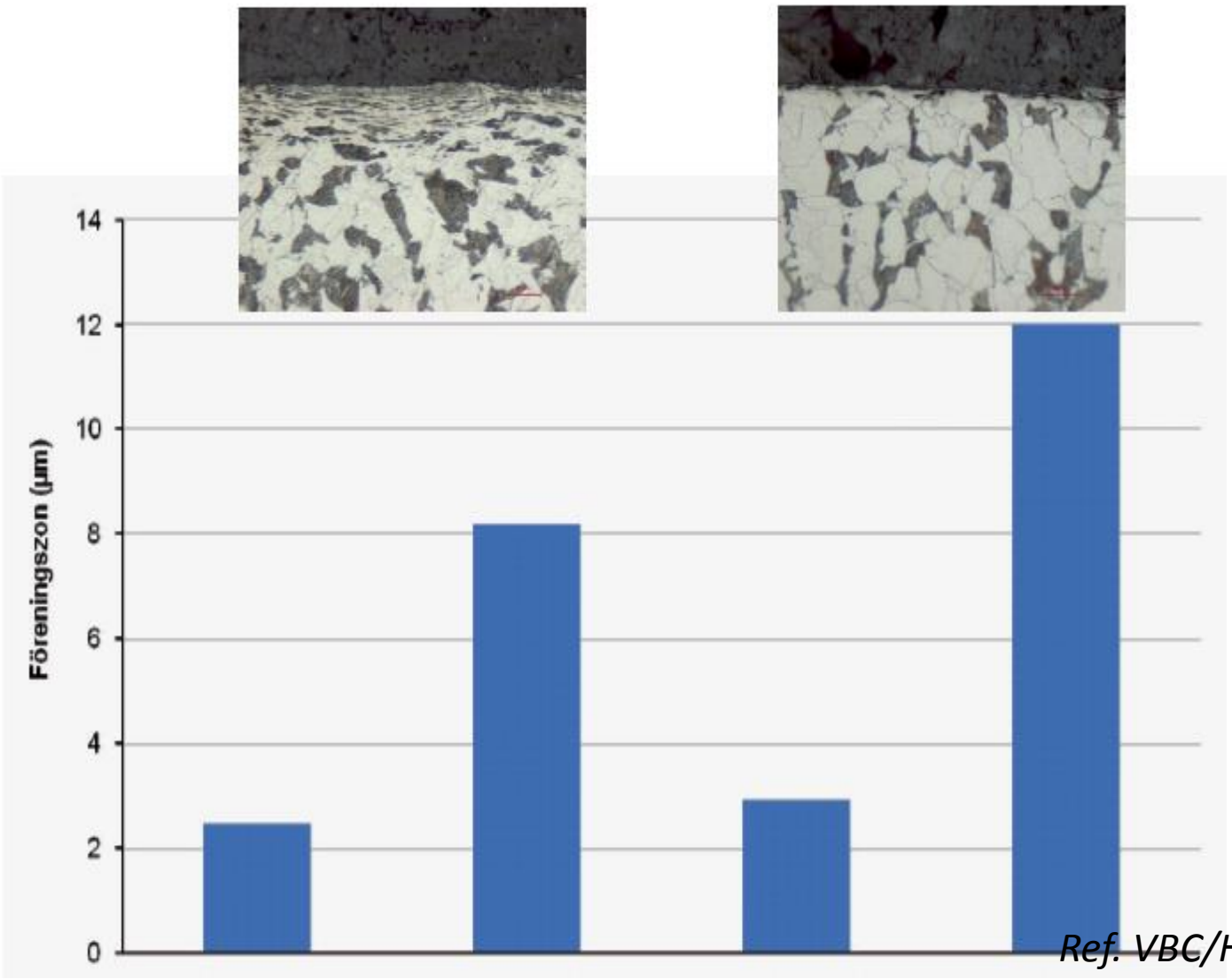
Background - Chemicals





Ref. VBC/Handboken

Background - Mechanical



Ref. VBC/Handboken

Background - Mechanical

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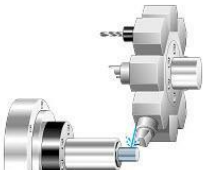
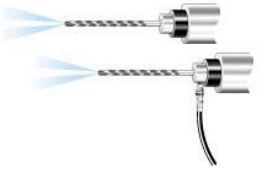
Machining Processes



Turning & Threading

Grinding

Milling



Deep hole Drilling

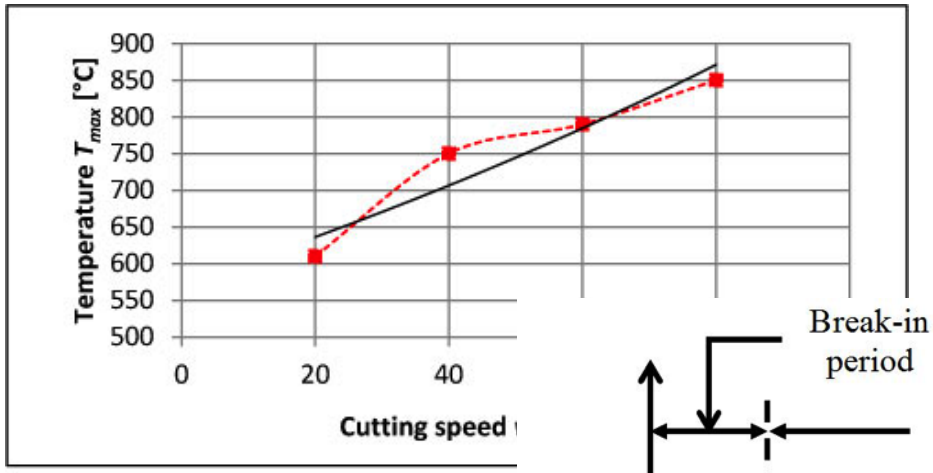
Honing

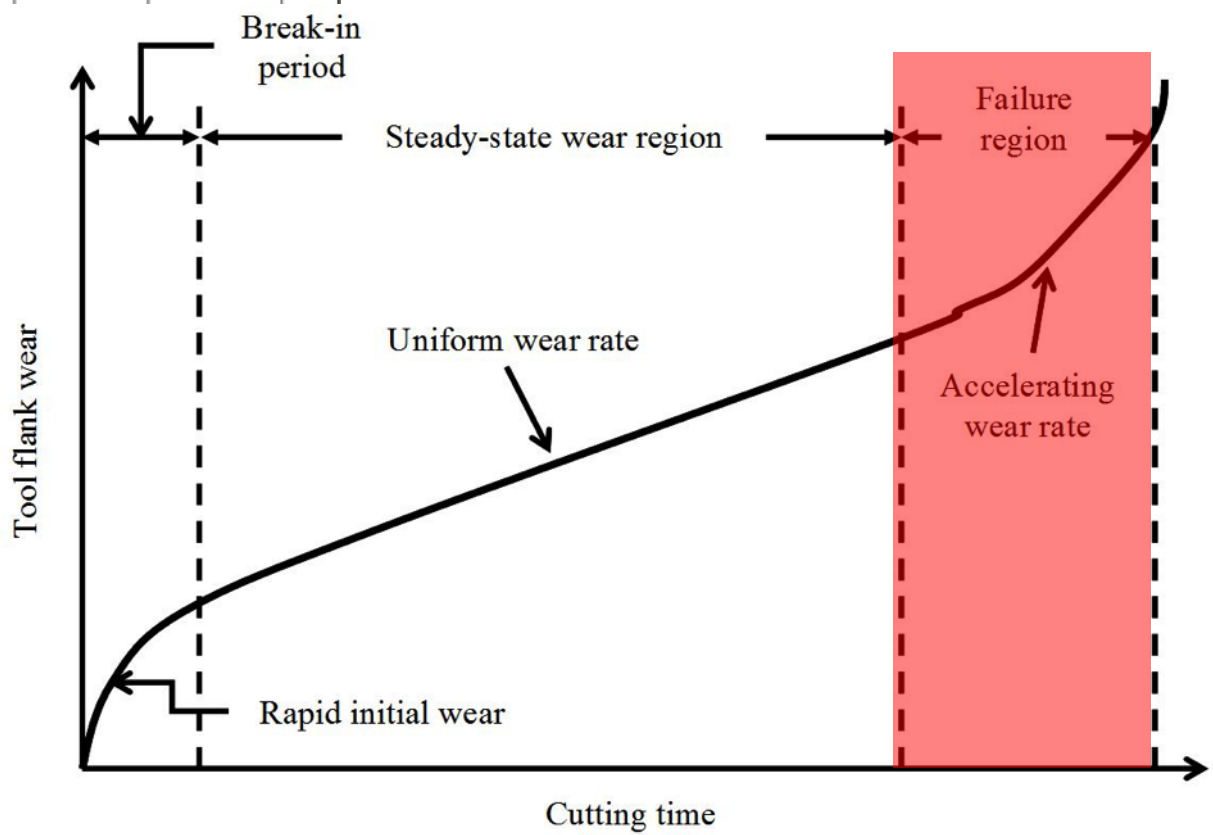
Polishing

Hazards

- Temperature
- Plastic deformation
- Contamination
- Reaction layers

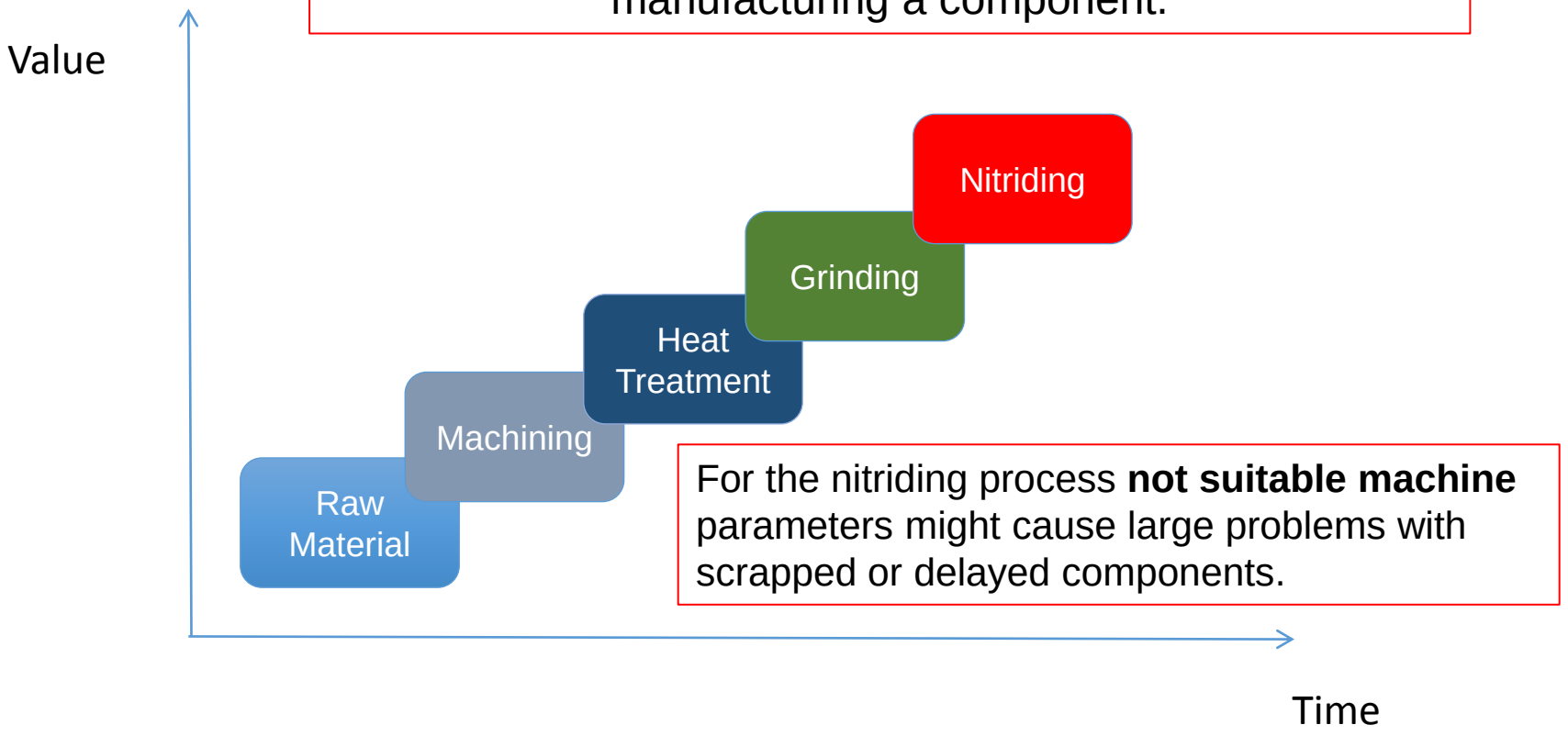
Background - Mechanical





Background

Nitriding is often one of the last process steps when manufacturing a component.



For the nitriding process **not suitable machine** parameters might cause large problems with scrapped or delayed components.

Nitriding requires a careful and professional surface preparation.

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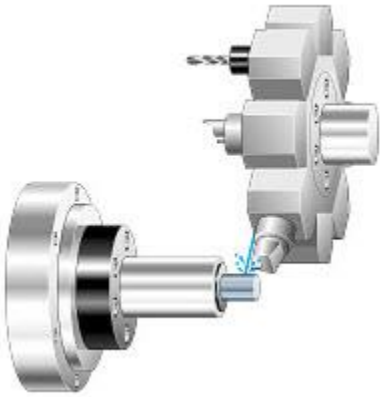
The influence of machining on the effects of nitriding

Part 2

Pawel Szulc

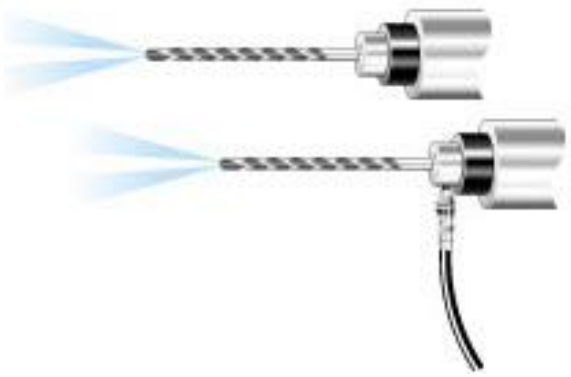
Machining types



Turning and Threading

Grinding

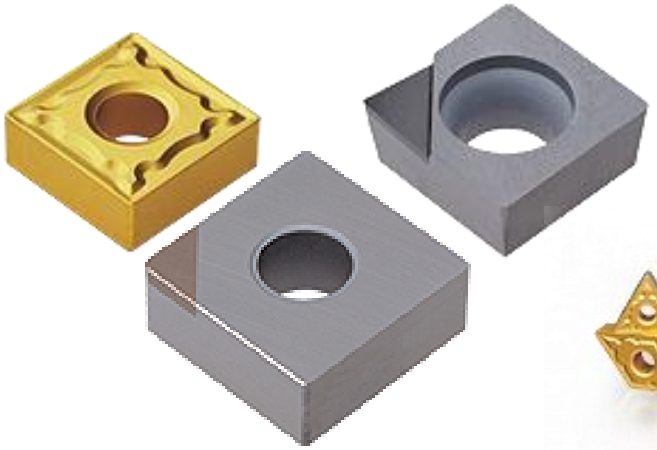
Milling

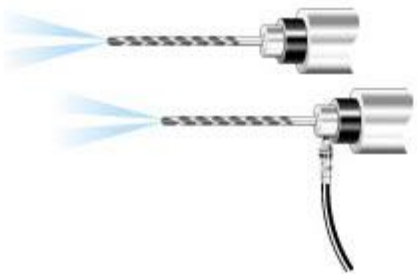


Deep hole drilling

Honing

Polishing





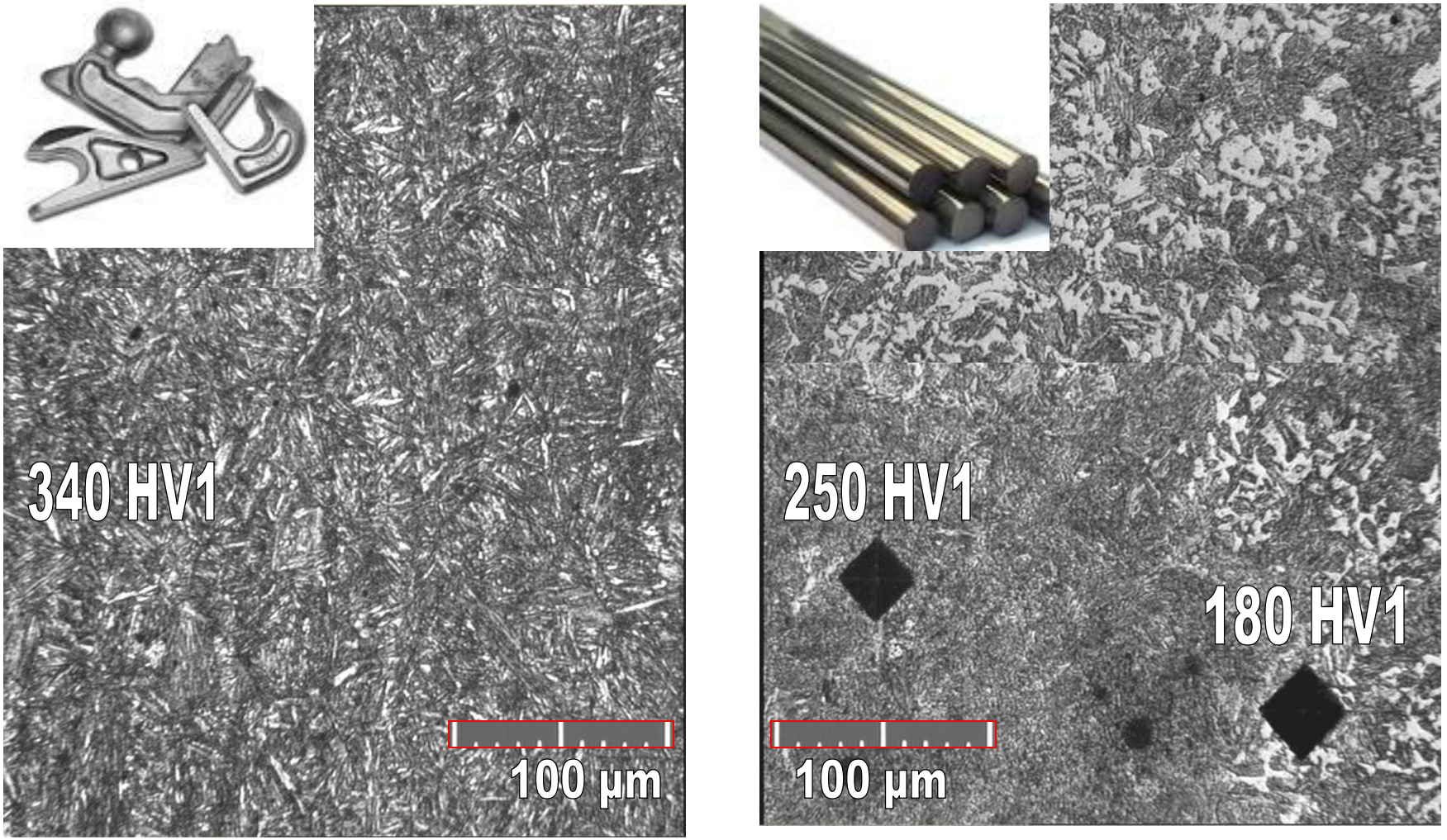
Modern cutting tools coated with many super-hard layers allow you to use very high machining parameters. In addition, they allow for performing standard operations on steels after heat treatment (hardness 30÷45HRC - this is their big advantage. At the same time, apart from the benefits, we should know the potential risks to deal with.

Raw material

Starting material hardness control

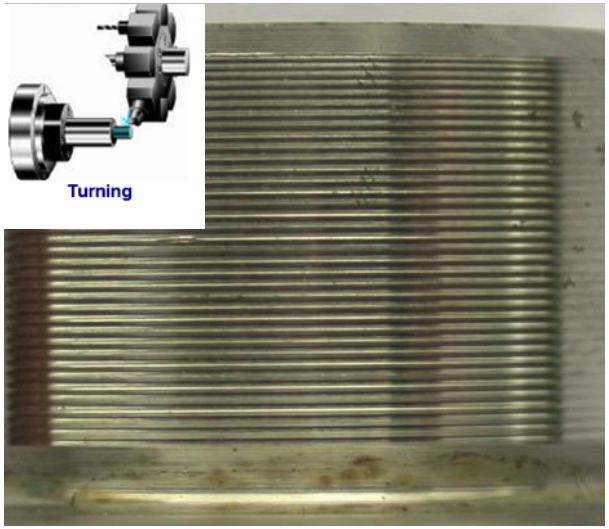
Any material intended for machining should have adequate properties to ensure the best parameters during the machining stage.

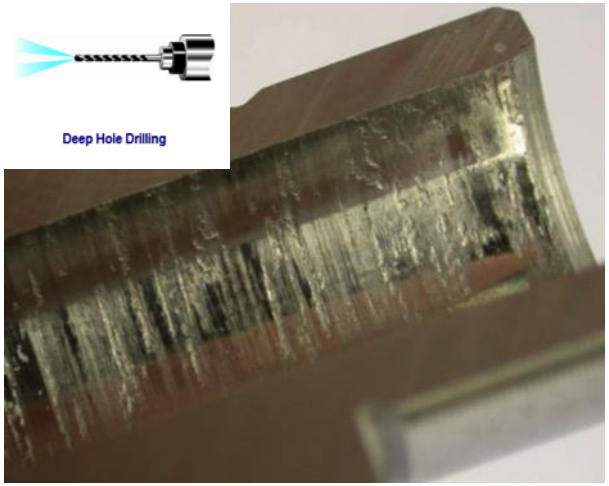
Raw material



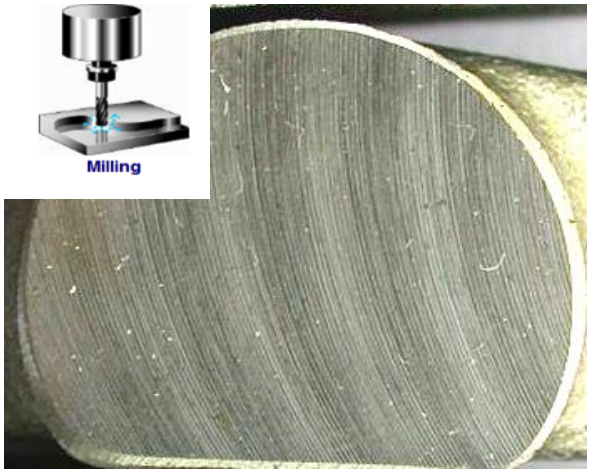
An additional aspect is the microstructure of the raw material, which has a significant impact on cutting parameters.

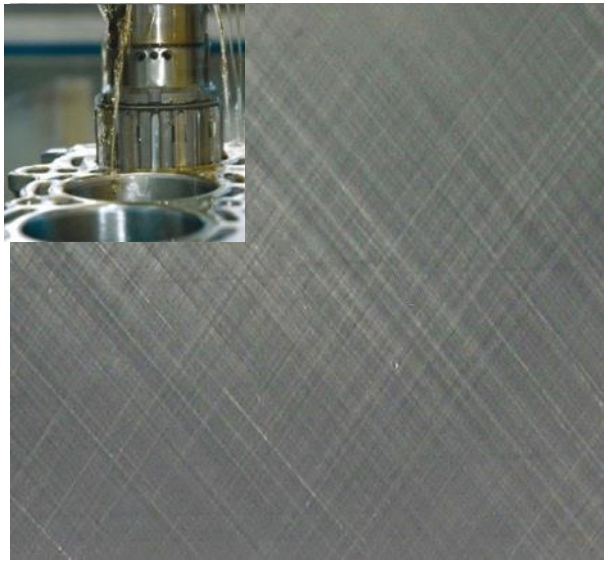
Surface inspection before Nitriding



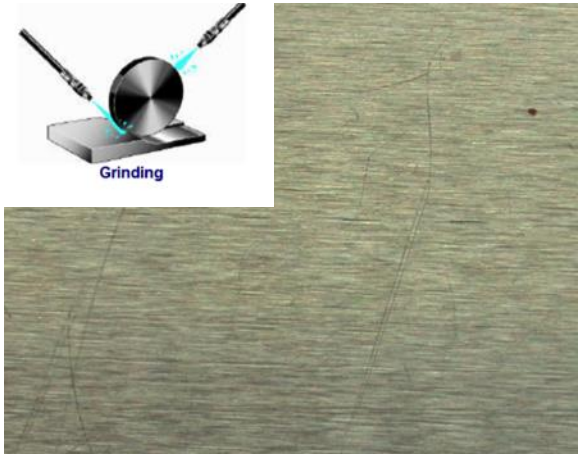


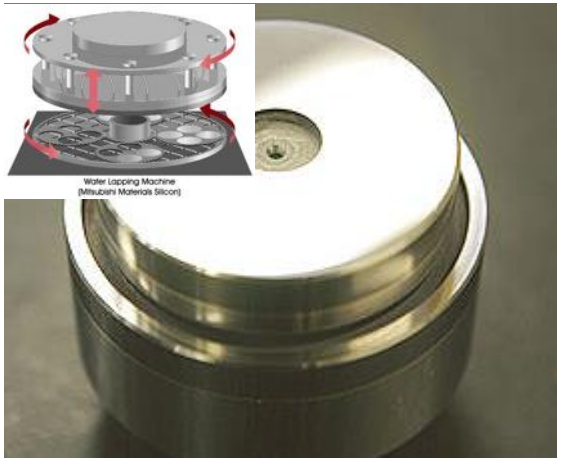
Surface texture
Roughness





Surface inspection before Nitriding





H13 steel		
Sample	Ra, before nitriding	Effective case depth@700 HV, (µm)
Ground	0,13	135
Polished	0,08	120
Lapped	0,04	85

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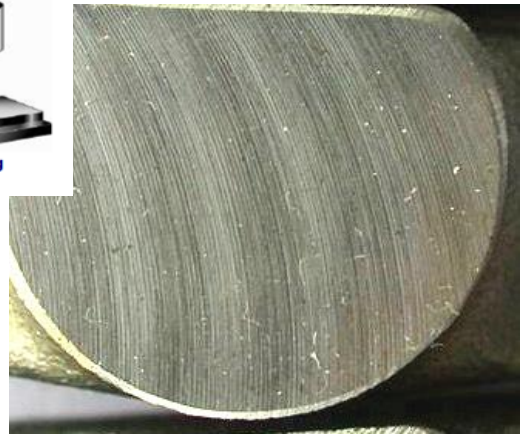
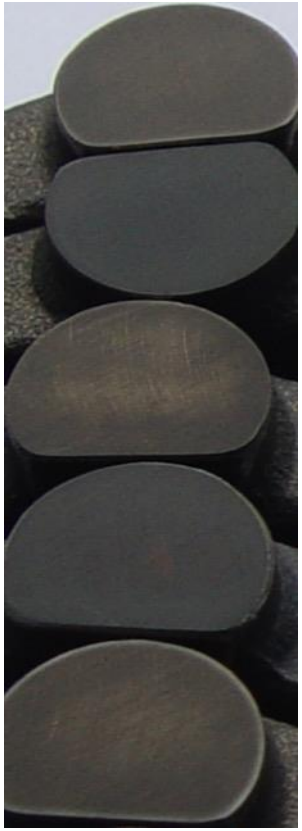
Potential differences on the surface of the workpiece

Before



After 4% Nital etching



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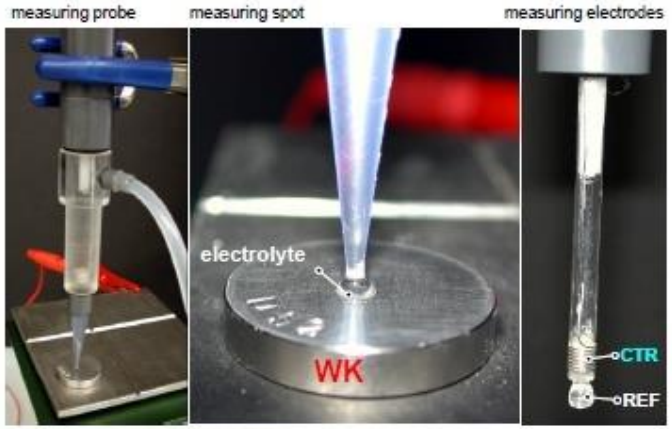
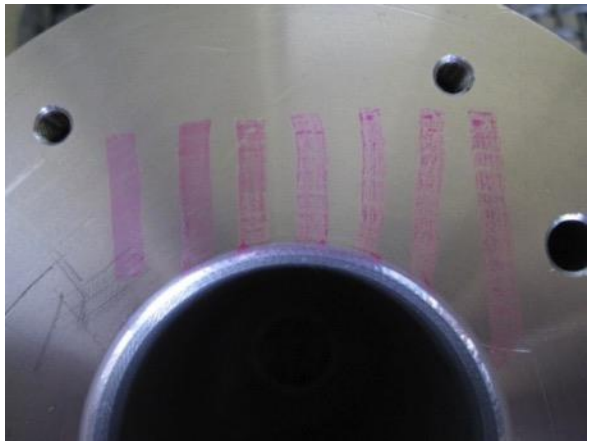
Cleanliness and activity



Electrochemical measuring probe



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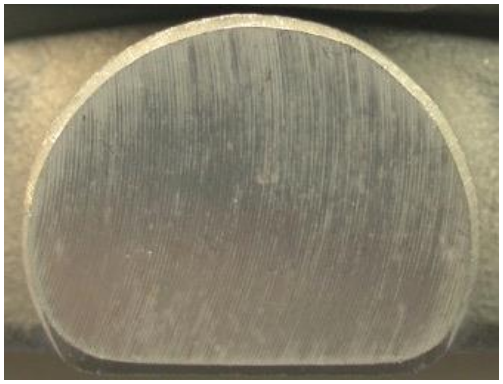
Defects revealed after nitriding - milling affect on workpiece surface hardness .

Surface hardness after milling
before nitriding process
340 ÷ 350 HV1

On 3200 parts surface color differences were observed
On 6800 parts, the correct case depth was observed

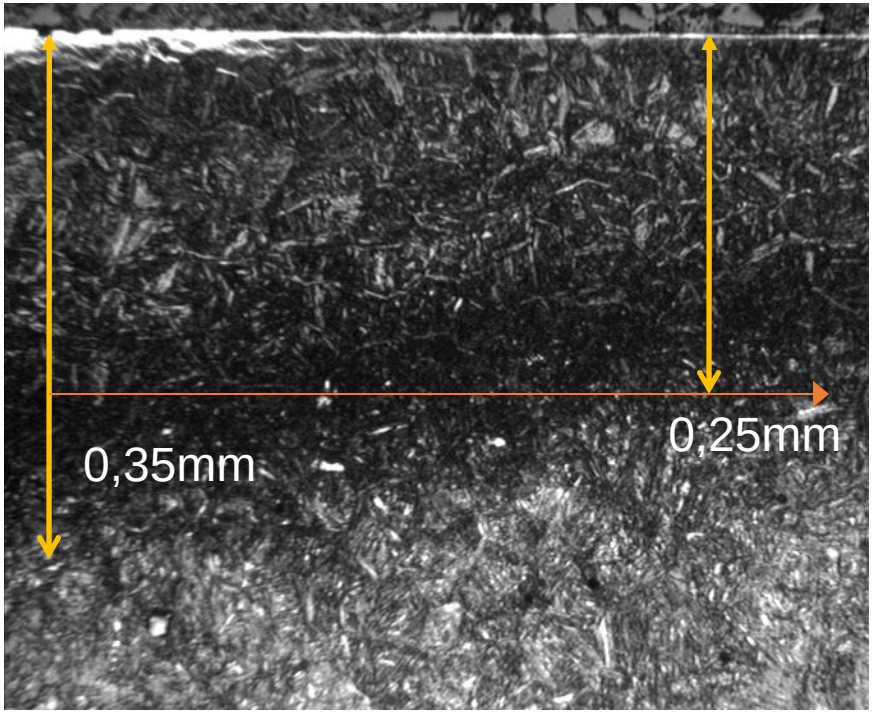


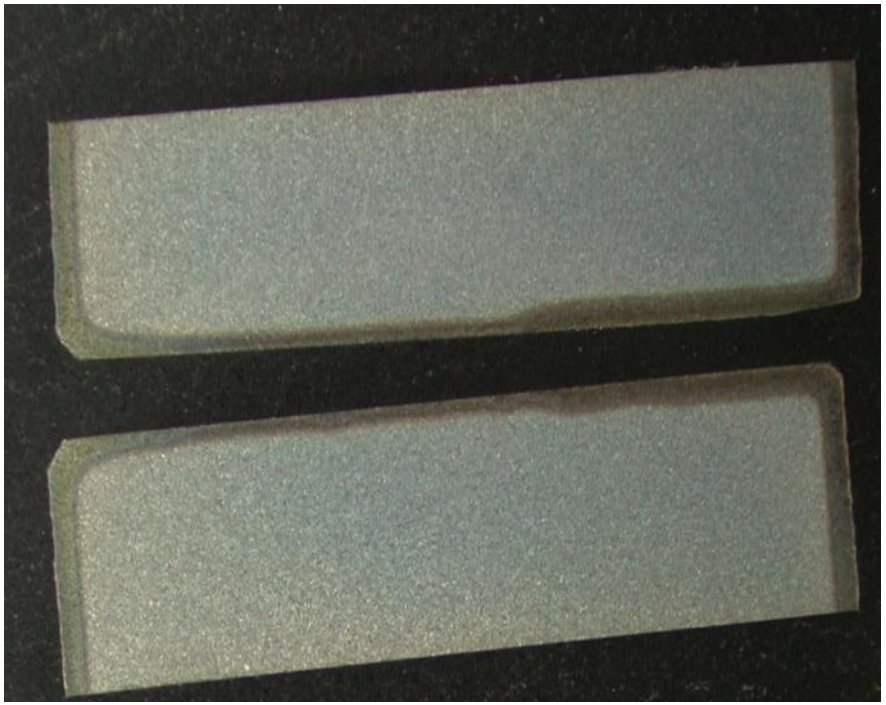
740 ÷ 900 HV1

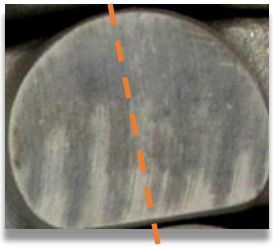
800 ÷ 1080 HV1

1080 ÷ 1140 HV1

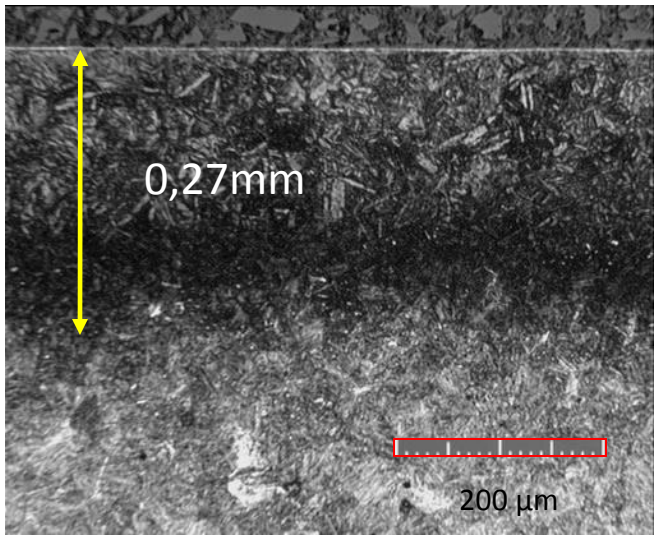
Macro-micro observations after Nitriding

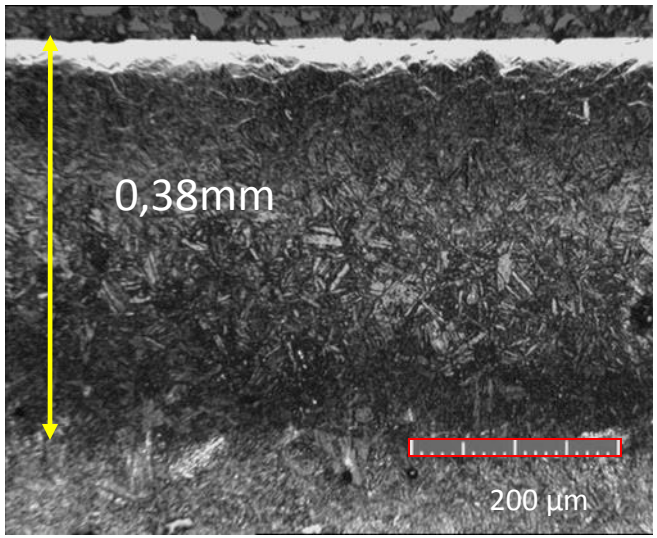


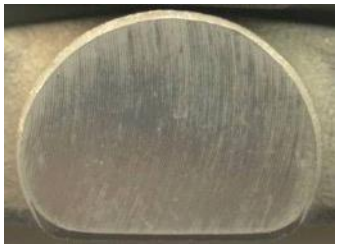




Macro-micro observations after Nitriding







Surface workpiece interaction with nitrogen during nitriding process

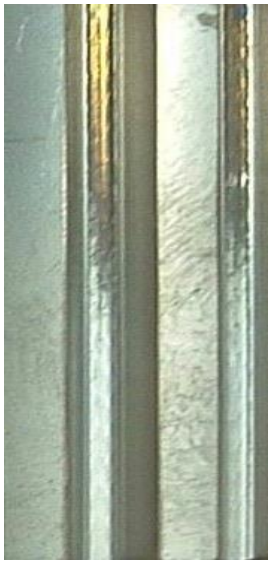
Macro observations after Nitriding

surface after drilling

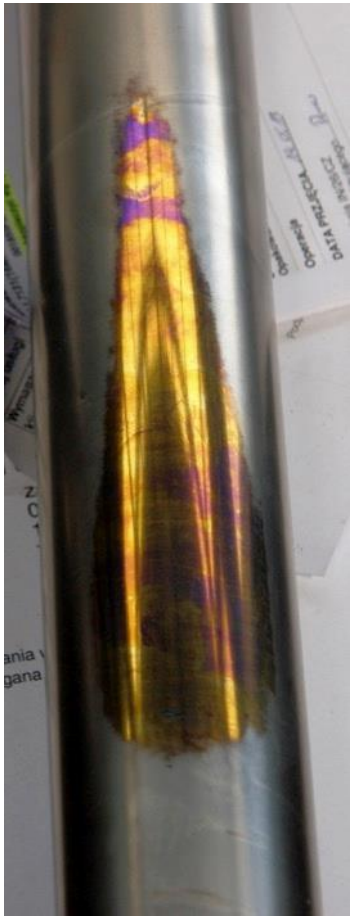
surface after honing

surface after milling

surface after hobbing of tooth space



surface after polishing



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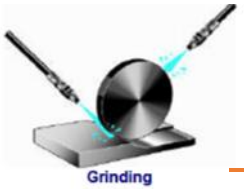
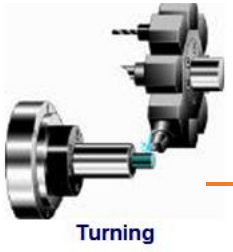
Macroscopic inspection has not revealed large differences in surface quality. Only the hardness measurement has shown significant differences in the effects of nitriding.





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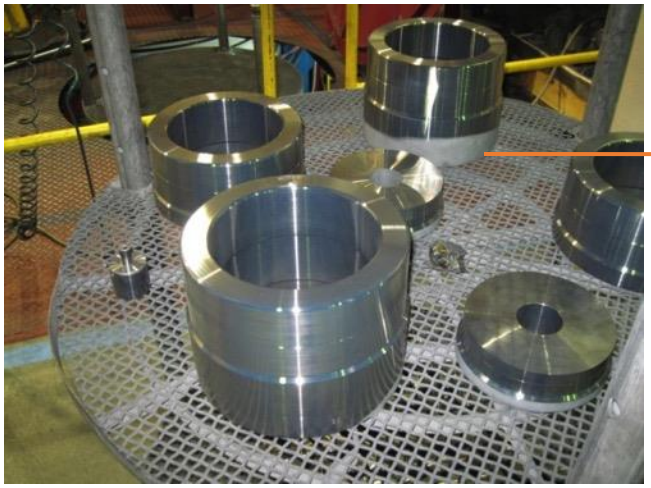
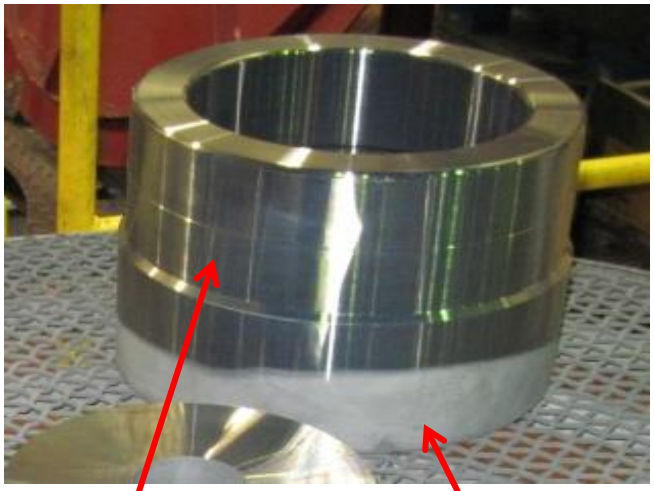
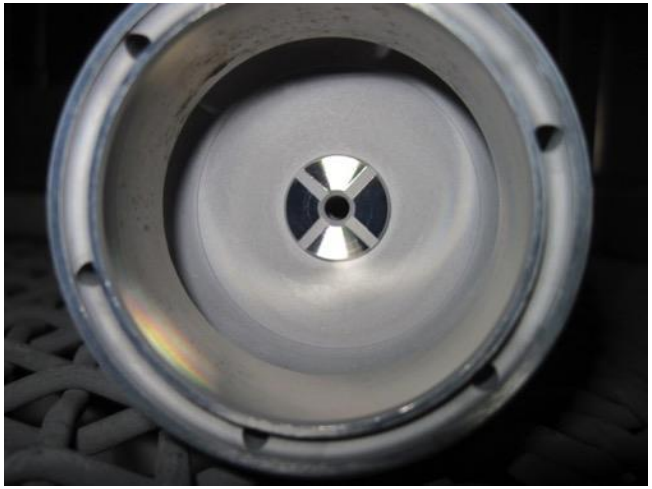
Machining and surface activation



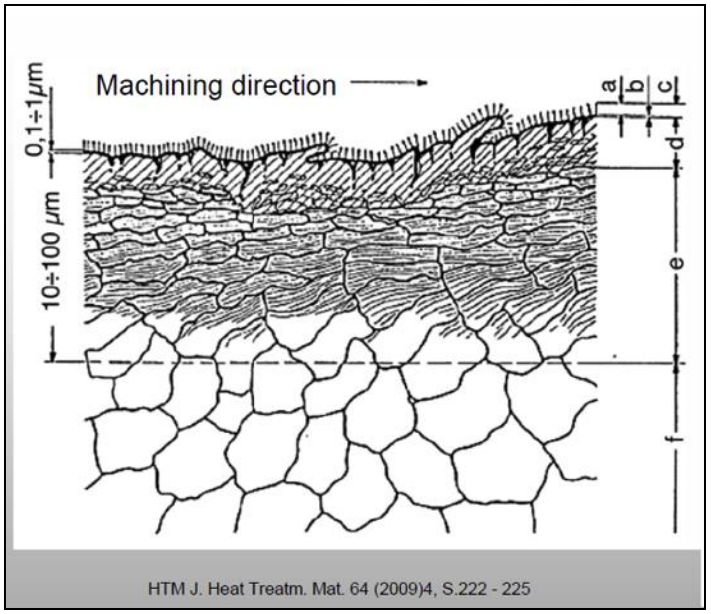




500 HV10

990 HV10

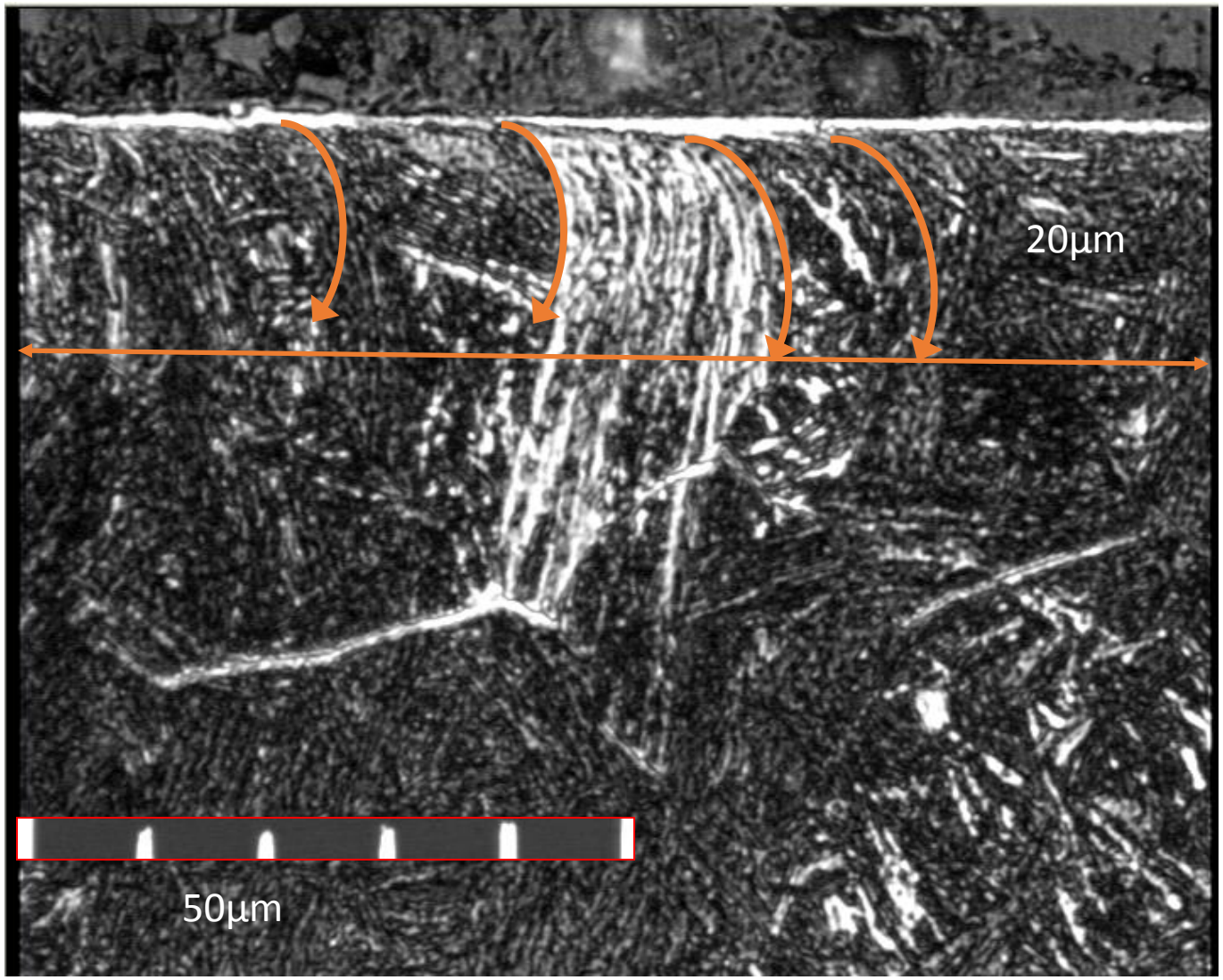
Defects after machining



the boundary layer consists of
a) *grease or oil film,*
b) *adsorption and reaction layer,*
c) *outer boundary layer,*
d) *transition zone,*
e) *inner boundary layer,*
f) *undisturbed metal structure.*

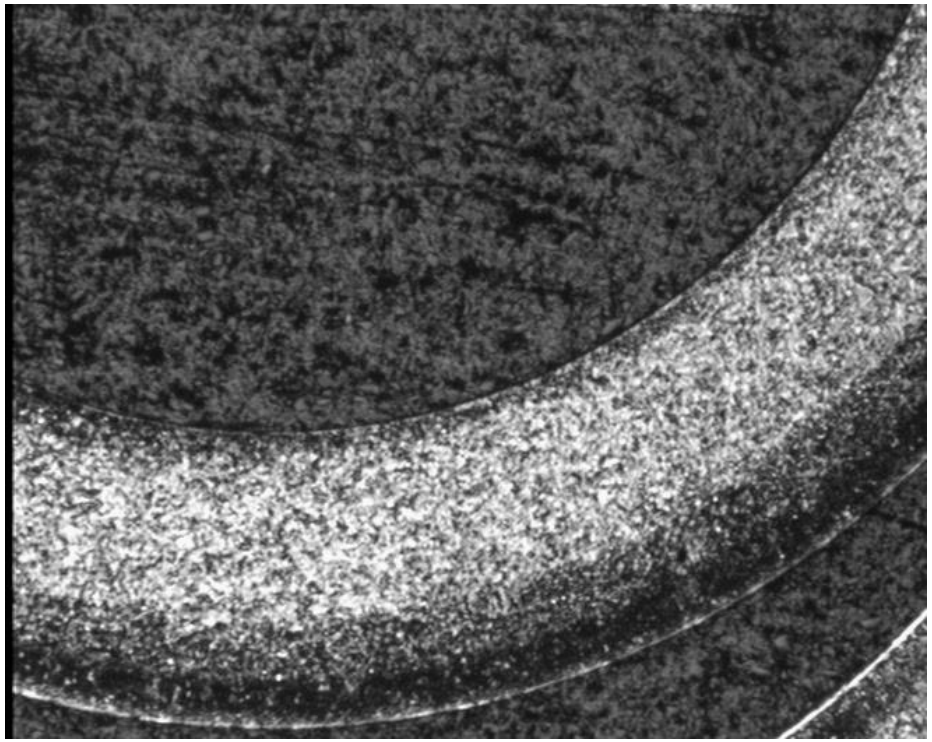
Surface preparation affect on the kinetics of nitriding process.

Defects after machining
grain deformation



Surface after drilling
Material: 41CrAlMo7
Batch weight: 1500 kg;
Quantity PCS: 500 pcs.

Deep Hole Drilling

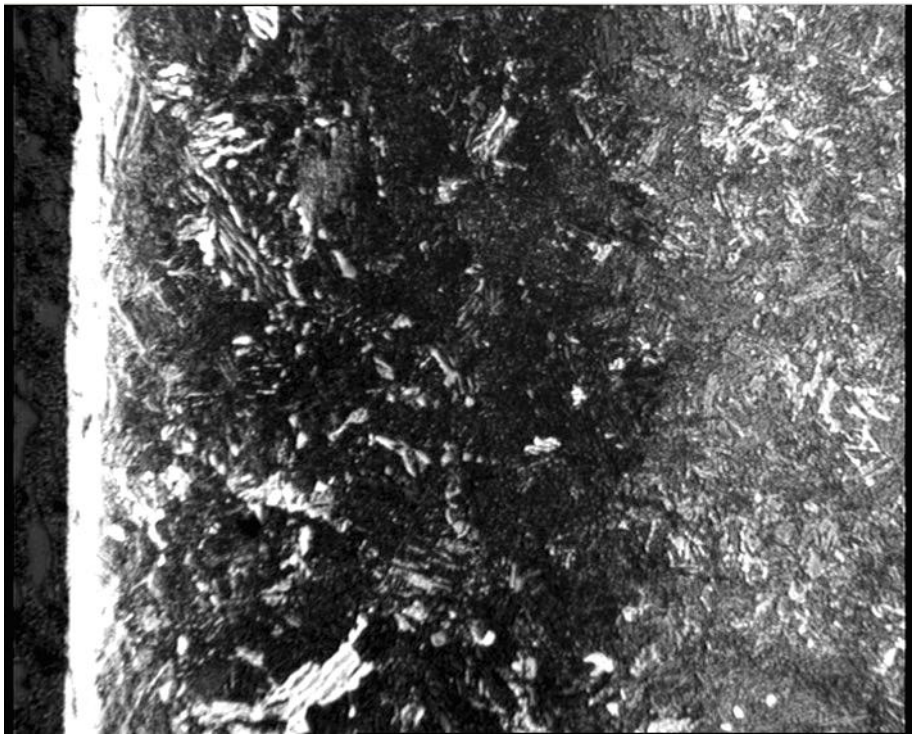


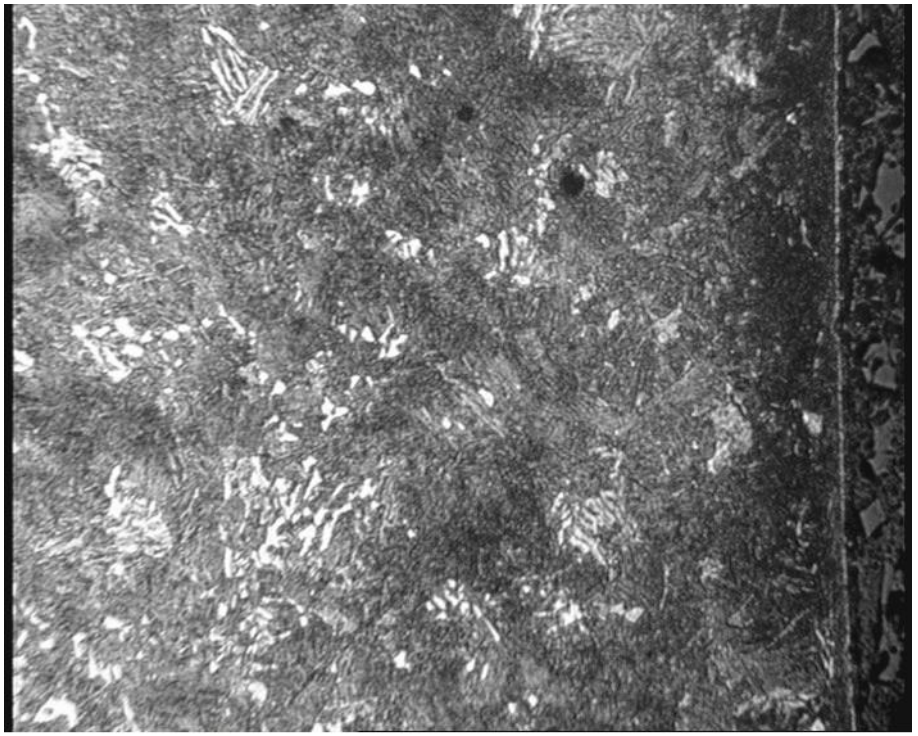
Turning

Defects after machining

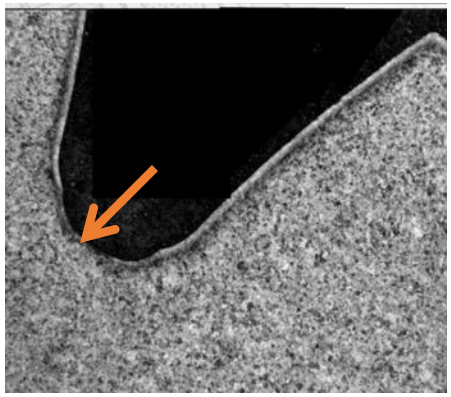
Turning

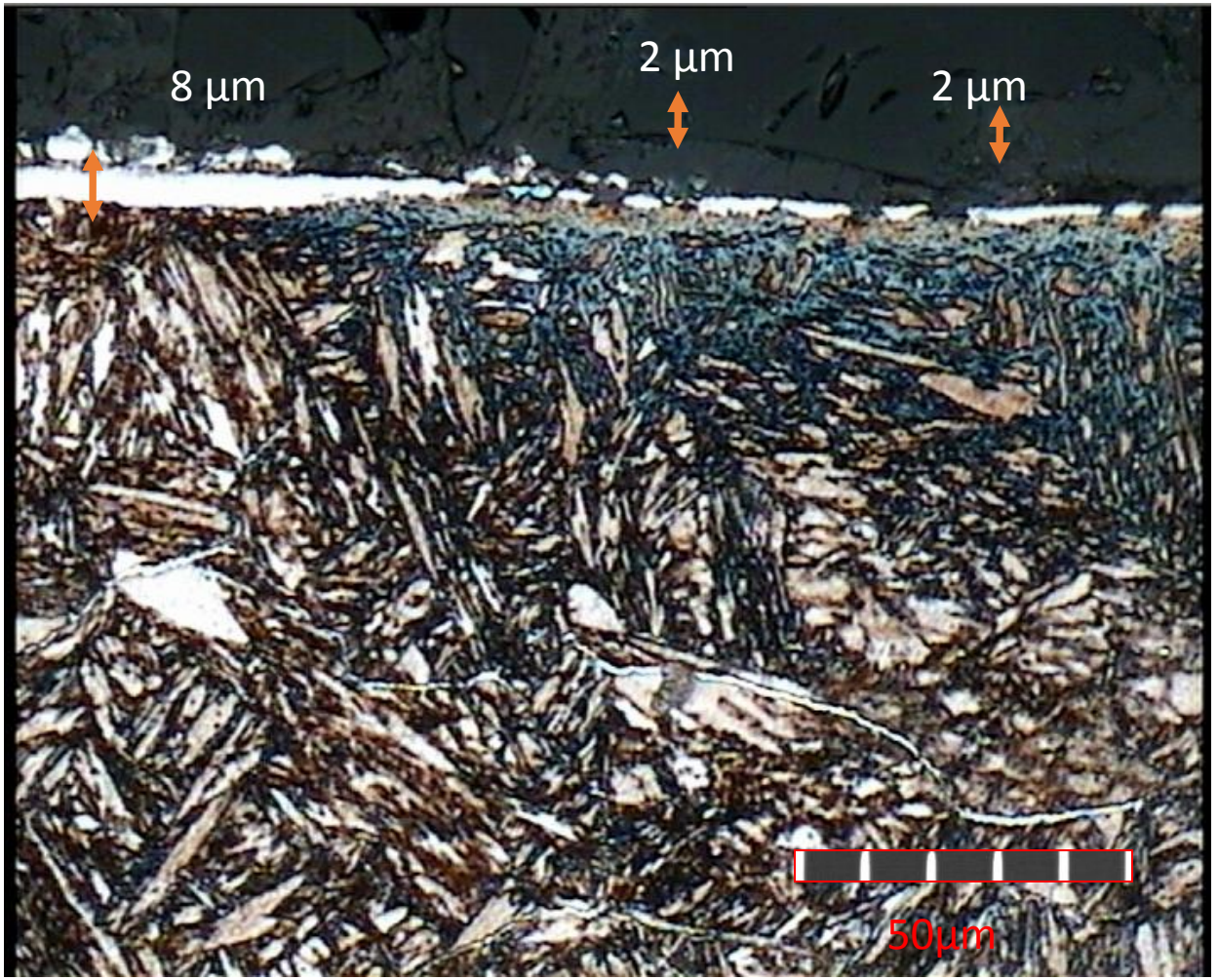
Deep Hole Drilling





Defects after machining





To minimize problems with different surface quality prior to nitriding it is recommended to perform surface activation.

Known ways of surface activation:
- chemical – oxidation, phosphating or etching in solutions of acids
- mechanical – sand/grit blasting, vibroabrasive treatment
- thermo-chemical during the nitriding process

Improve the nitrogen diffusion rate at the gas-solid interface.

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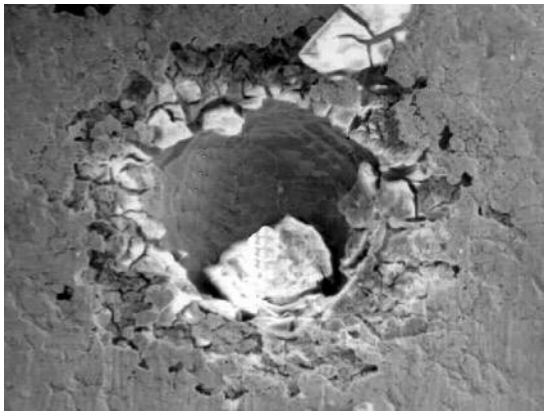
Mechanical activation



- proper abrasive material selection (grain size)
- blasting parameters (p, t)
- precise cleaning

Surface activation before Nitriding process

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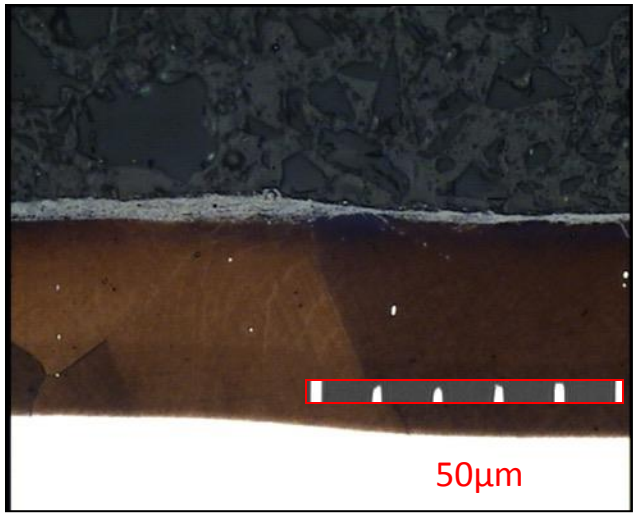
Nitro-M®

- Thermo-Chemical process
- Tool-steels
- Passive surfaces
- No impact on surface roughness
- Normal Nitrocarburising characteristics; *Compound layer, hardness, nitriding depth etc*



Surface activation before Nitriding process

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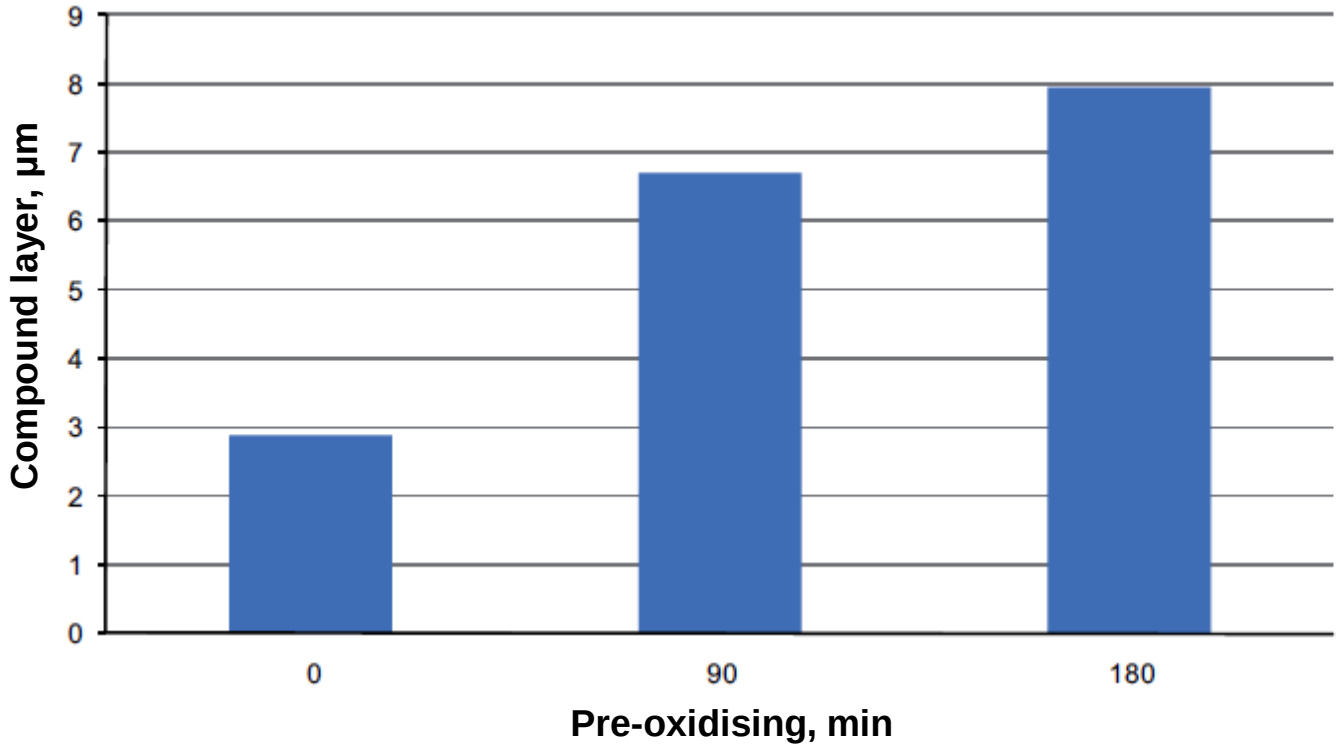
Pre –Oxidation



Effect of pre-oxidation on nitrocarburising results.
Nitrocarburising 580°C 45min, steel 42CrMo4

- Surface condition have essential influence on Nitriding process successful

- Clean surface does not mean optimal preparation prior Nitriding

- Special care must be focused on machining stages due to Nitriding is last operation to get final product (feedback between designer, tool shop and hardening shop)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