IMPACT TESTER CONTACT CYCLIC TESTING

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- The components in many industrial aplications are exposed to intensive effects of contact load
- Degradation occurs during the contact stress of two surfaces because of their interaction

Degradation – the limited factor of service time

This is why methods for elimination or at least controlling such degradation are sought.

impact testing

Impact tester:

• possible to determine the response of materials to dynamic impact contact wear

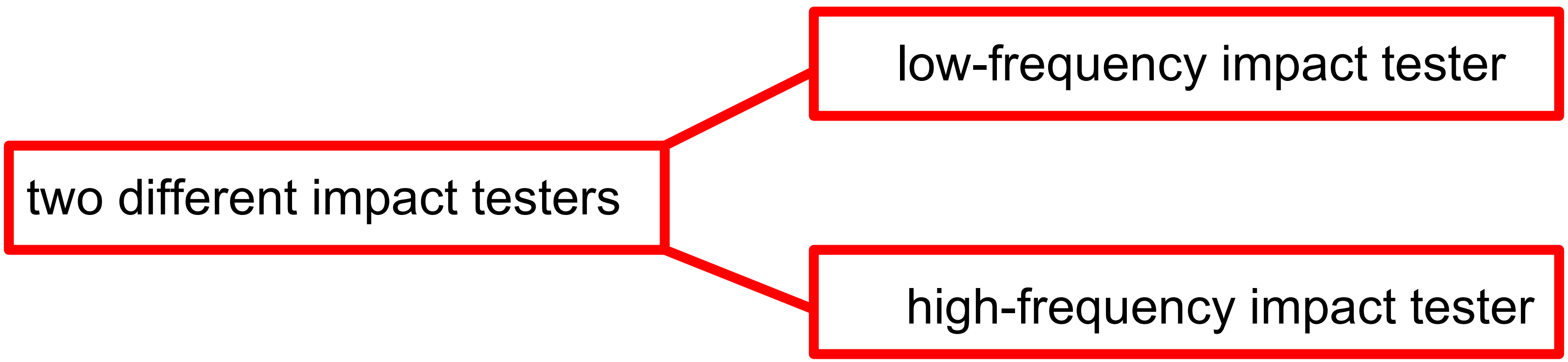
• the resistance to impact contact load can be examined not only in bulk materials but also in surface-treated materials

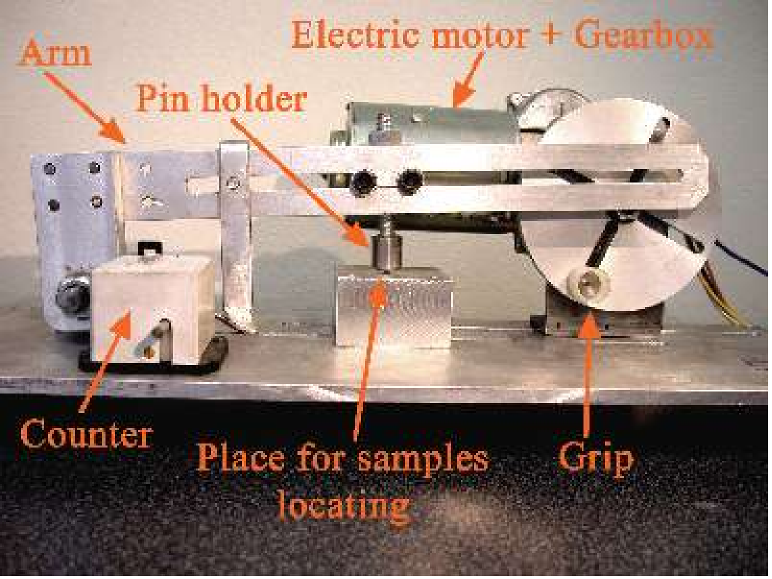
• investigation of <u>contact impact fatigue</u>

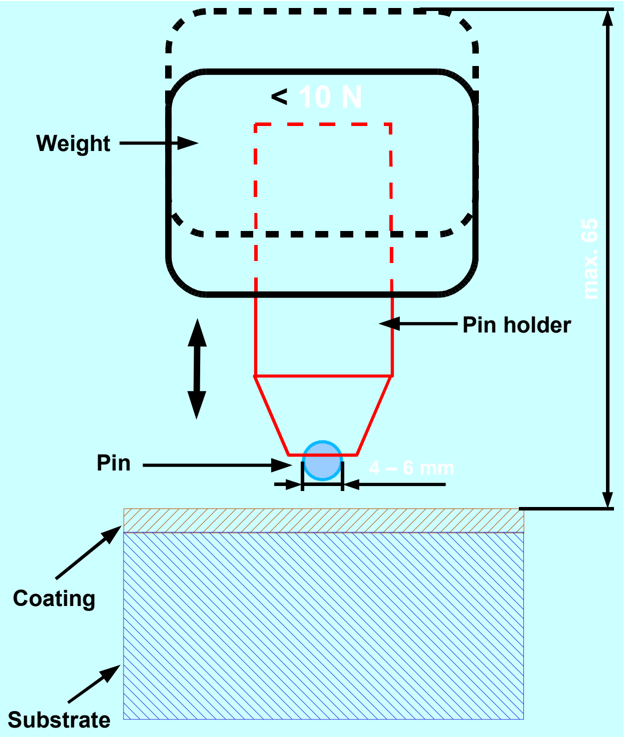
Dynamic contact wear does not rank among the basic wear modes - combination of mechanisms involving adhesive, abrasive, fatigue and vibration wear

Why Impact testing?

- testing based on scratch-test techniques or tribological procedures might be inadequate for simulation of conditions, where the surface of material is subjected to both fatigue load and erosive wear. The impact test is a more accurate simulation of a real-world situation affecting the service-life of material (e.g. “pulsating” contact between the cutting tool and work piece due to vibrations).







low-frequency impact tester

-low frequency of impact - about 0.8 Hz

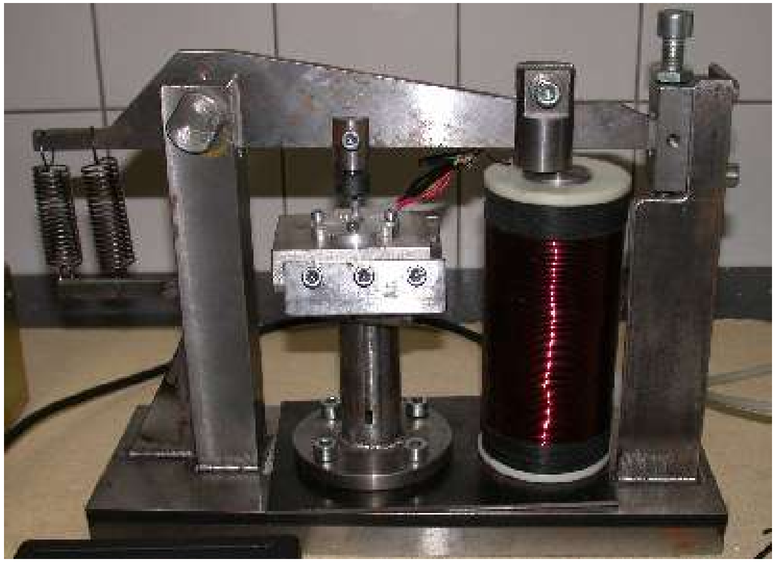
-the impact energy of the indenter can be changed by changing the drop height

-the indenter on the specimen can be accurately set as perpendicular to the surface, depending on the height of the specimen

-a weight of up to 1,000 g

-indenters – 4 – 6 mm ball

-easy to determine the impact energy (as it is proportional to the potential energy of the indenter)



high-frequency impact tester

-indenter is attracted by electromagnetic coil

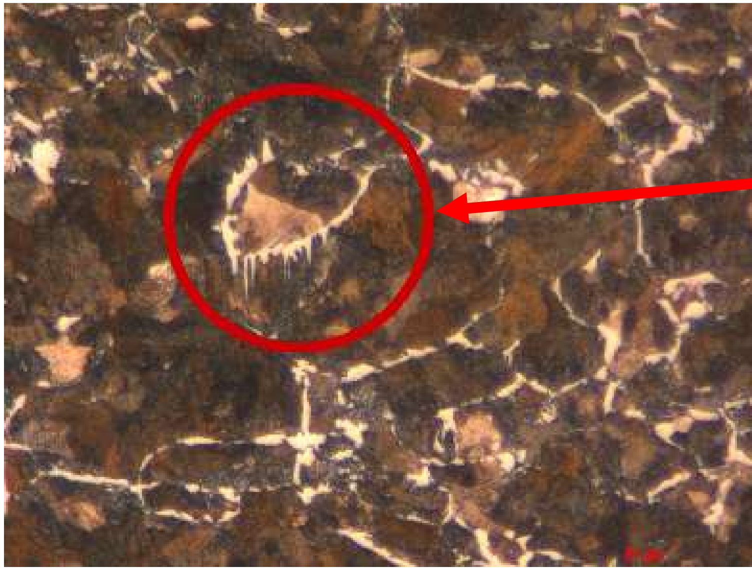
-up to 50 Hz

-accelerometric and acoustic emission measurements

-the holder with the indenter are returned to their initial position by a spring force

-the test piece is mounted on a rotating and extending stage

The Use of Impact Testing for Rail Vehicle Wheel Materials



-ferrite and pearlite structure and some areas of Widmannstätten-type microstructure

-Impact testing provided no evidence of the Widmannstätten microstructure being the initiation site for cracks

-indenter was a 6 mm diameter tungsten carbide ball

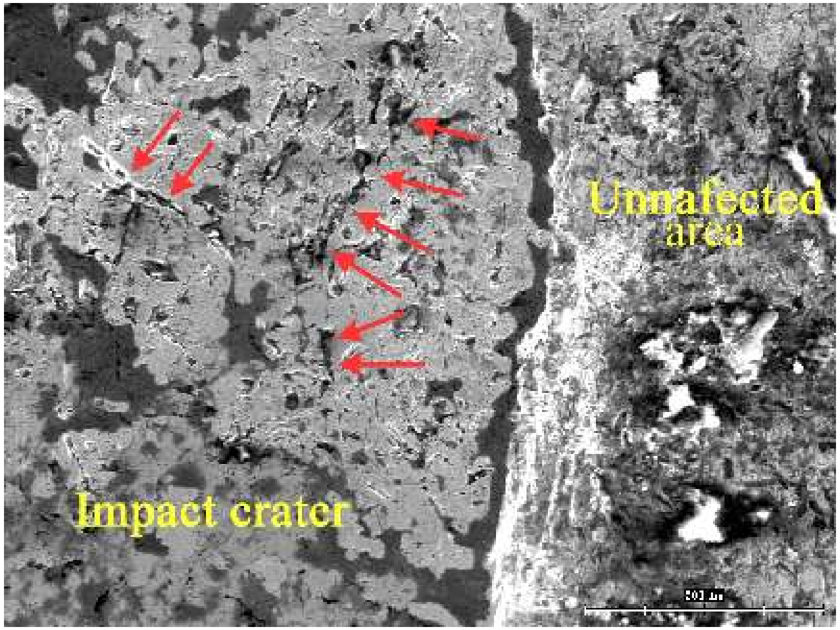
-impact energy of E = 0.078 J

-In order to clarify the damage mechanism and to capture the progressive wear of the specimen surface and the formation of impact sites, various numbers of impacts were used for the test: 500; 1,000; 2,500; 5,000; 10,000 and 100,000

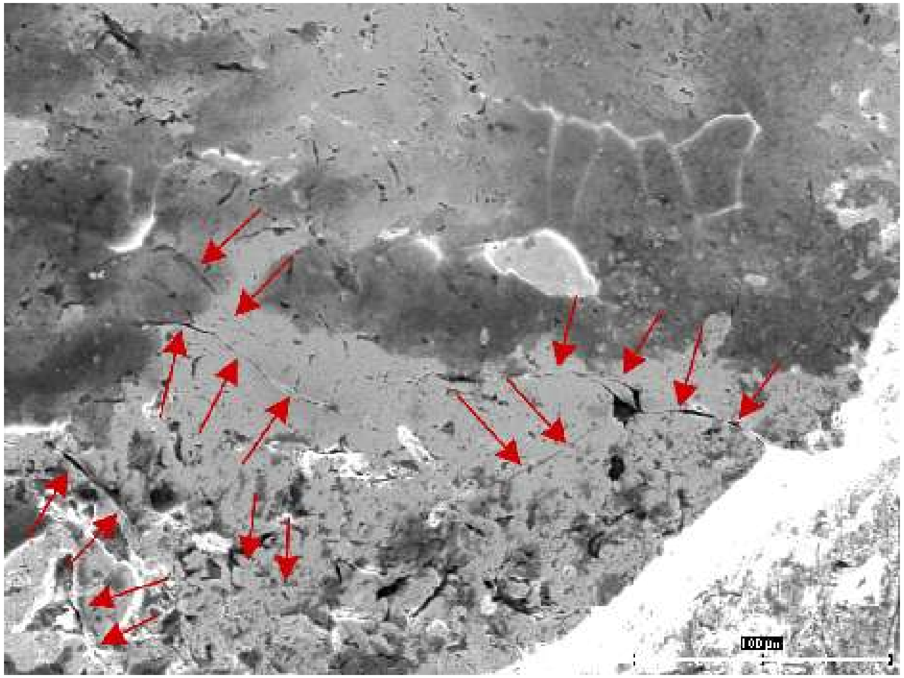
500 impacts

-numerous defects were observed in the fringe area of the impact site

-after as few as 500 impacts, numerous defects were observed in the fringe area of the impact site



1000 impacts



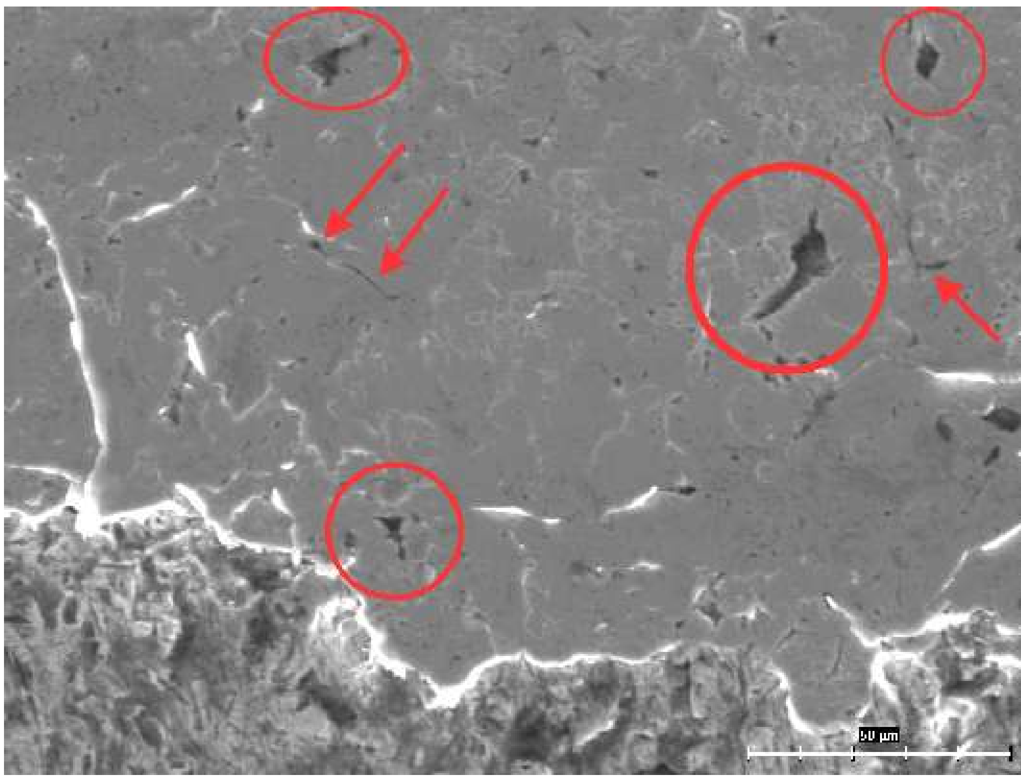
-the fringe area of the impact site showed a network of fine cracks

With the growing number of impacts: - number of defects in the fringe areas of the impact site was decreasing; number of defects in the centre of the impact site was increasing

-the concentration of the bulk of defects in the fringe area of the impact site is related to the distribution of the tensile stress, which reach their peak in this location

-prevailing type of stress in the impact site centre is the compressive stress

100 000 impacts



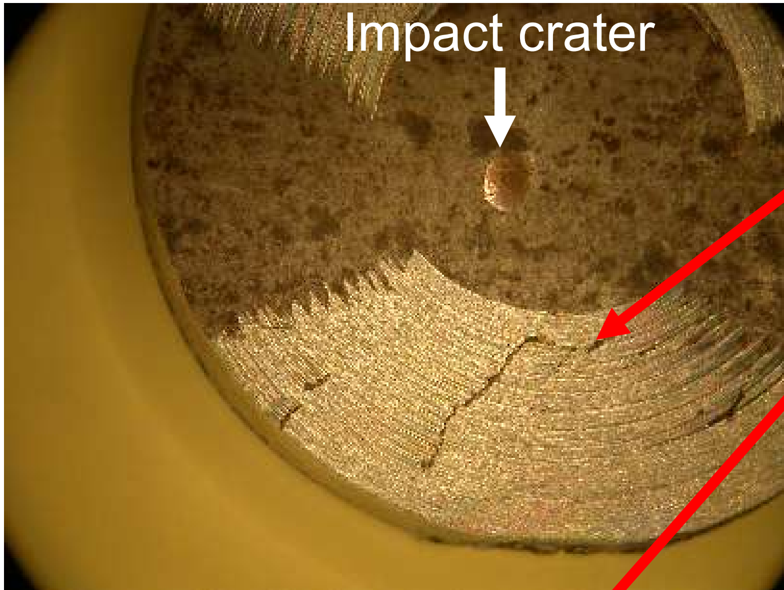
-the crack from machining rapidly propagated

-crack was outside the impact site

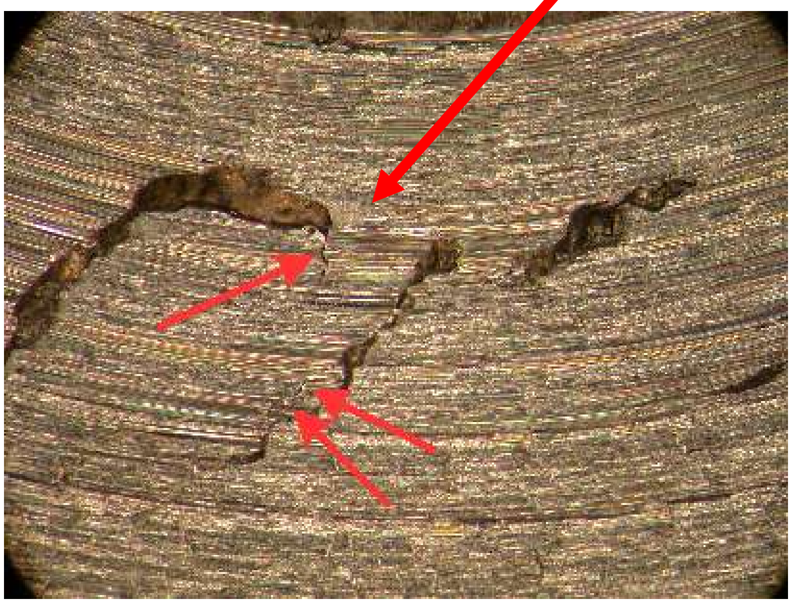
-view of the impact site fringe area:

clusters of defects (marked with a circle

hairline cracks (marked with an arrow).



crack propagated from the area of specimen (which was under the clamping flange that held the specimen in the testing instrument)



-it can be assumed that the crack propagation was due to the propagation of the impact load throughout the whole volume of material

-the shock waves emanate from the impact site and reach all parts of the material

-the shock wave energy reduces the critical stress for the crack growth

Impact Resistance of Wear-Resistant Thin Films in Cutting of Difficult-to-Machine Steels

-another area - machining using tools with PVD-deposited thin films

-impact test offers accurate simulation of the cutting edge load during cutting of a difficult-to-machine material and models the shocks acting on the tool surface due to interrupted cut (e.g. milling)

-determination of the moment of the film failure and delamination where the substrate becomes exposed due to the dynamic contact is very important for the real-world cutting tools

-upon delamination of the film, the revealed substrate of the tool is not capable of resisting the adverse conditions in the cut area and the cutting edge is destroyed immediately

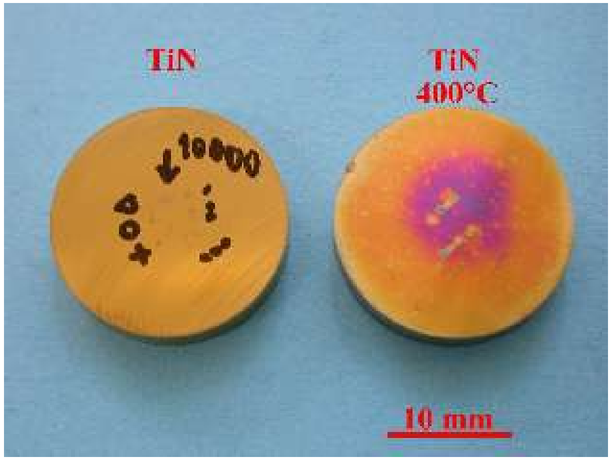
-the purpose of the experiments was to find the impact loading resistance of certain PVD coatings

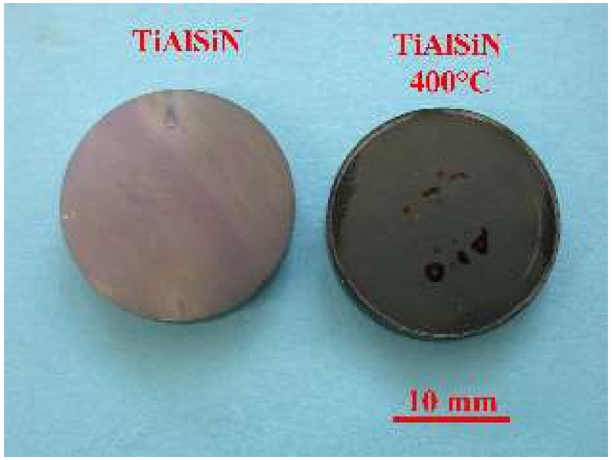
-most common industrial PVD films: TiN, TiAlN, TiAlSiN deposited on ISO K20 (sintered carbide substrate)

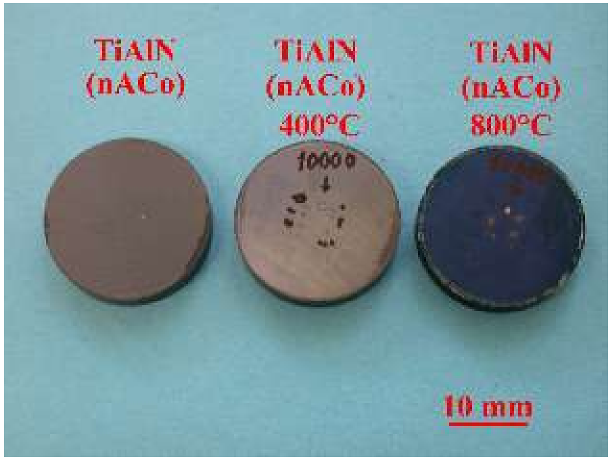
-the measured response of the films was correlated with results of other measurements:

- nanoindentation
- fretting test
- tribological measurements
- technological machining tests - turning and milling a difficult-to-machine material: X210Cr12 (AISI D3) tool steel heat treated to 55 - 56 HRC

It is known that heating causes certain types of coatings to form oxide films, which may increase their resistance to wear ⇒ the films were heated - 400°C for all films and to additional 800°C for the TiAlN film







Nanoindentation measurement:

TiN - the most favourable plastic/elastic strain ratio of all films, heat load resulted in slight softening of the film

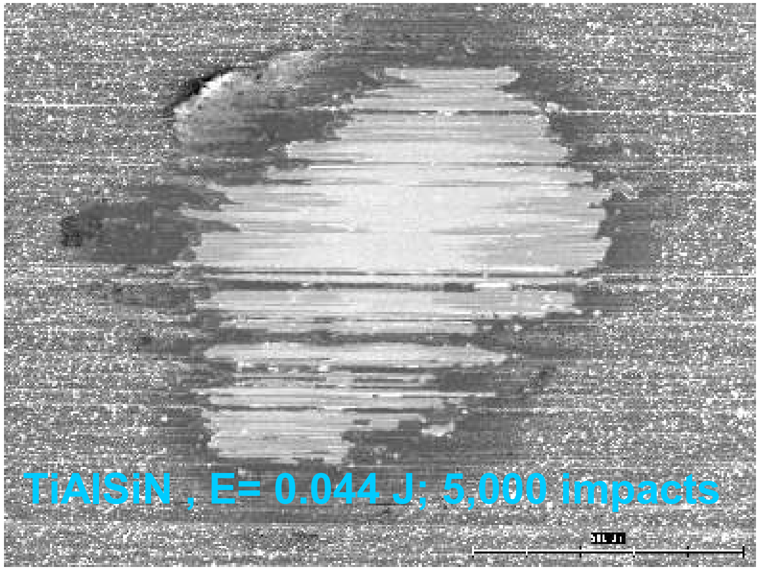
TiAlSiN - high hardness, more brittle than the TiN film

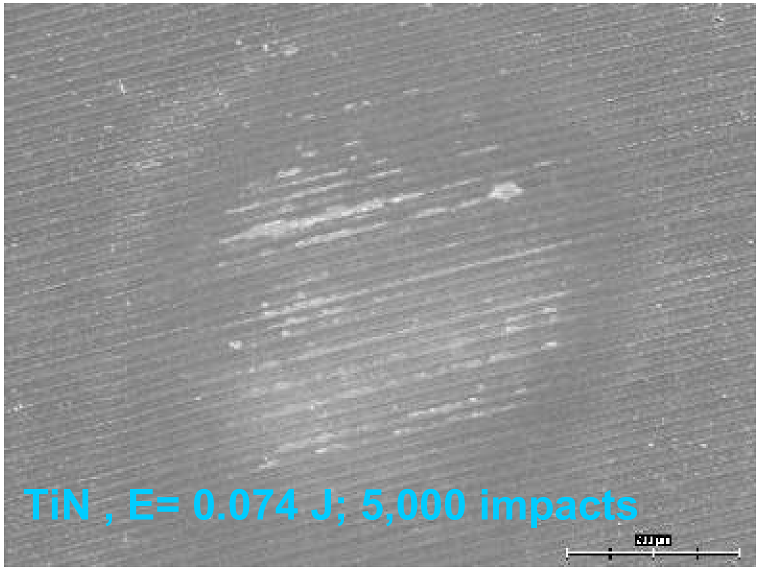
TiAlN - heated to 400°C ⇒ microhardness and brittleness increased

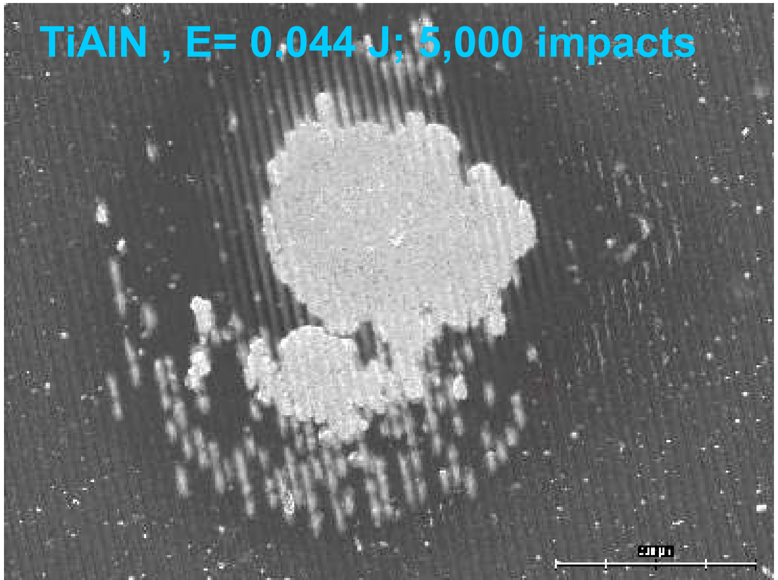
heating to 800° ⇒ microhardness decreased while its toughness increased

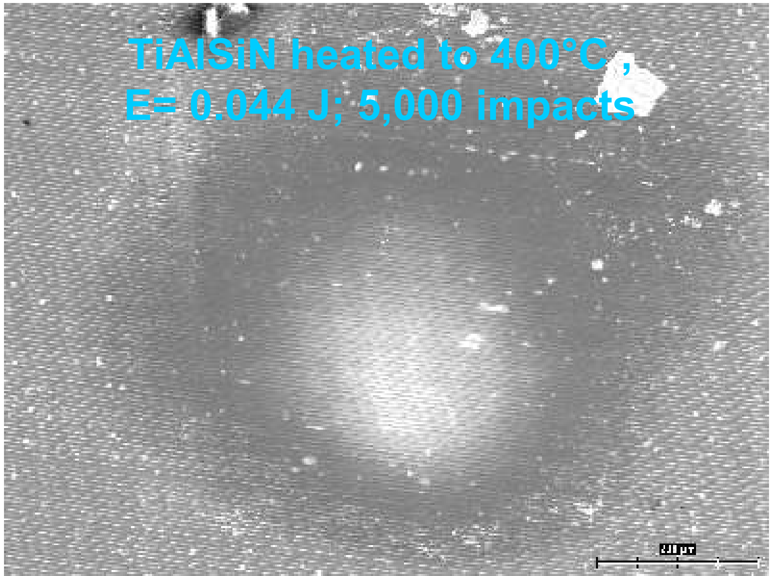
-F= 2 N (E= 0.044 J) and F= 5 N (E= 0.074 J)

-1,000; 2,500 and 5,000 impacts.









TiN

- after 5000 impacts systém did not show any significant damage

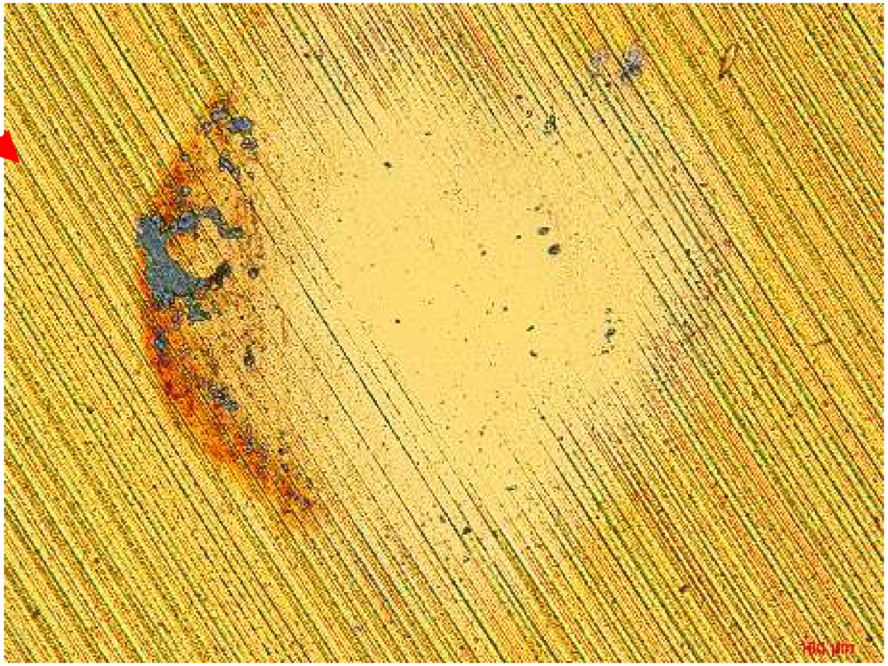
→ very good „damping“ capacity

- 400°C – increased resistance to impact loading

- Very good properties of this film stem from its very low thickness and good elastic-plastic properties – confirmed by nanoindentation measurements (high plastic strain to elastic strain ratio)

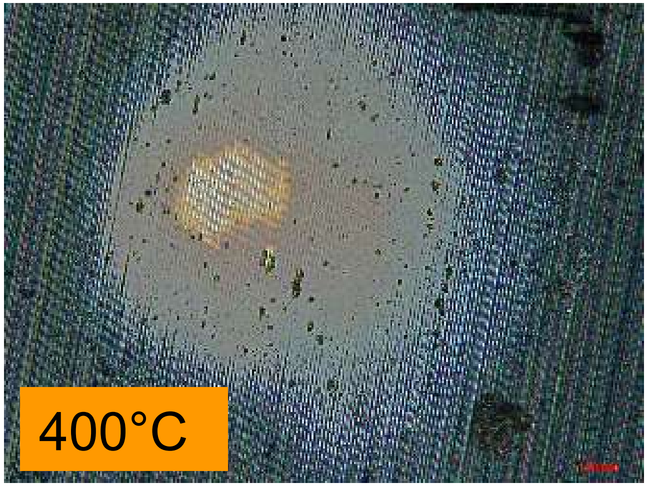
TiN , E= 0.074 J; 5,000 impacts

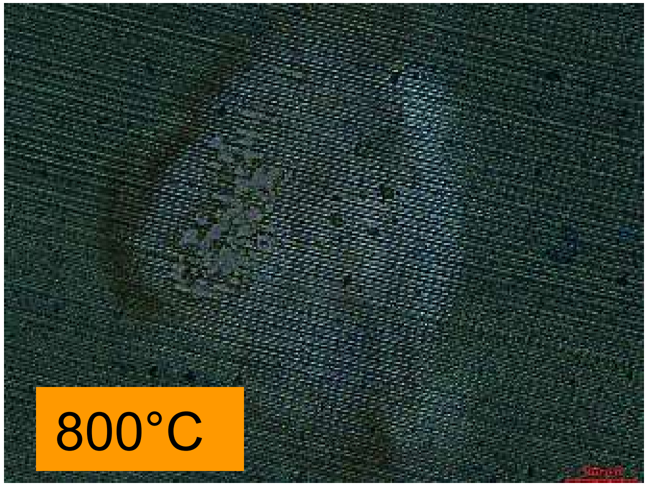
400°C

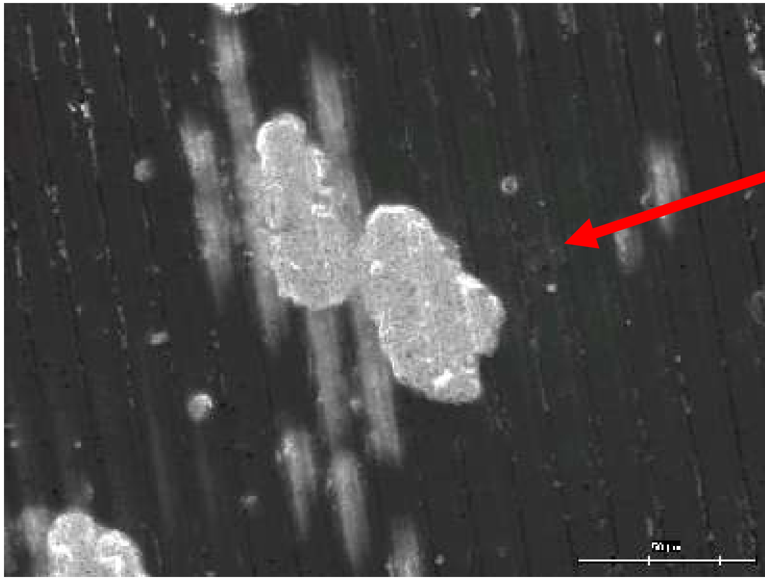


TiAlN

- Traces of wear were observed even at 1000 impacts (E = 0,044J)
- such damage occurs in the roughness pattern
- The peaks transmit all impact energy → their fast flattening
- After 2500 impacts (E = 0,074J) – extensive damage in the film and delamination from the substrate across the whole impact crater
- Heating to 400°C improved resistance to impact failure (in contrast to the non-heated-film)
- Heating to 800°C clearly improved its resistance to contact fatigue damage further

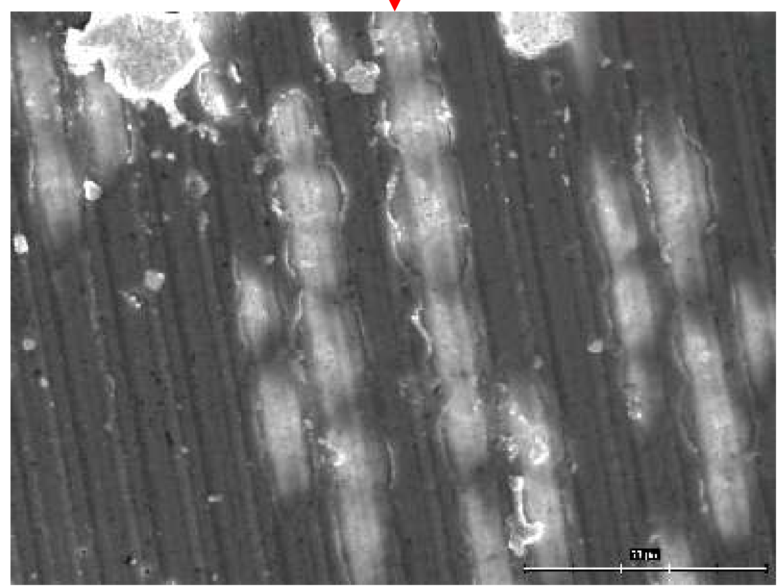






The impact site in the TiAlN film upon 1,000 impacts, E= 0.044 J - detail of the substrate revelation

detail of the TiAlN film damage mechanism on the impact site prior to substrate exposure



TiAlSiN

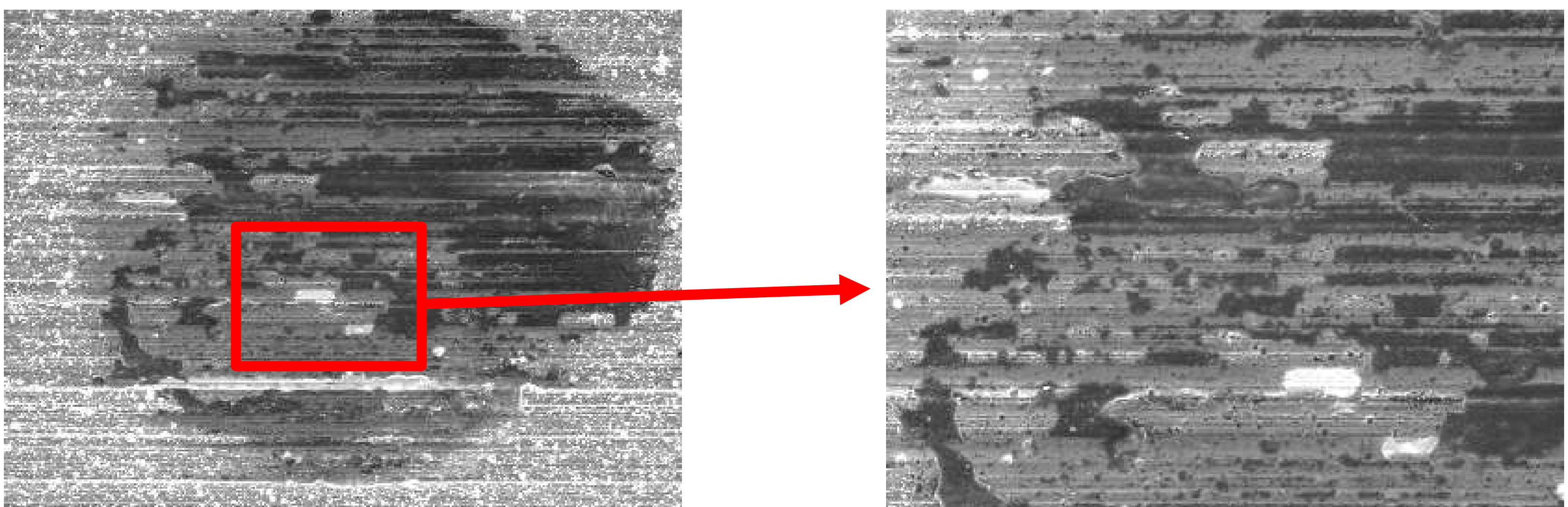
-lowest resistance to the impact fatigue wear

-top TiAlSiN layer became severely damage; adhesive TiN layer was efficient in preventing the overall wear of the film

-nanoindentation measurements: high microhardness and lower toughness

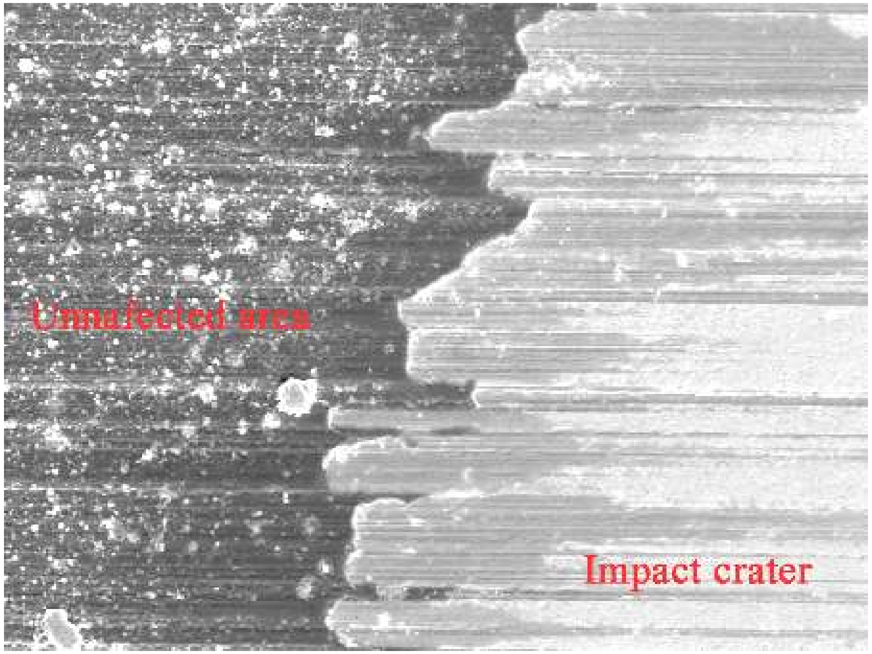
-macroparticles – are surrounded by stress field

5. contribute to the wear of the basic coating
6. May get pulled out from the coating and thus compromise the cohesive strenght of the film



TiAlSiN

- overall delamination of film



Conclusion

-The impact tester represents one of the newest and most promising methods for investigation of behaviour of materials subjected to impact contact load.

-examination of behaviour of <u>not only</u> bulk materials but also that of surface films and coatings

-The instrument can be expanded with additional measuring equipment:

- accelerometric measurements
- acoustic emission-based methods - the formation and propagation of impact-induced cracks

-The high-frequency impact tester (50 Hz and higher) provides data for plotting Woehler curves $\Rightarrow$ the residual life of a part can assessed using a small sample taken from the part

Thank you for your attention