Running-in phenomena in combustion engines

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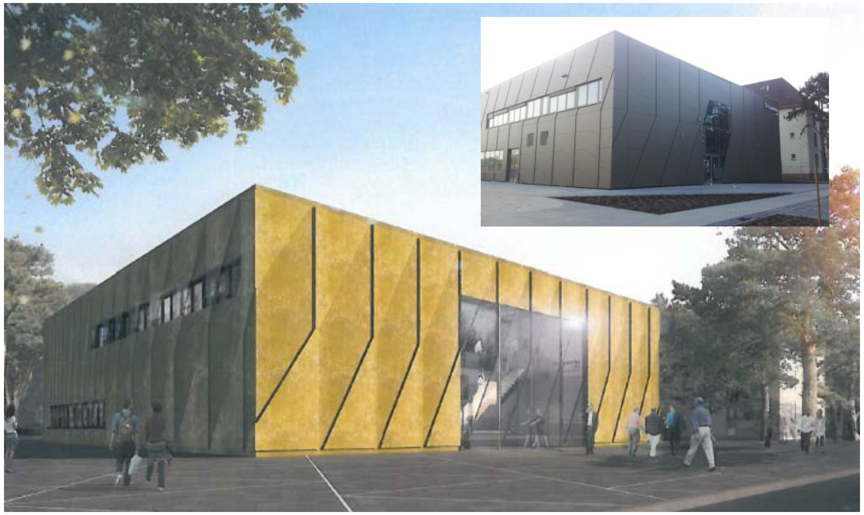
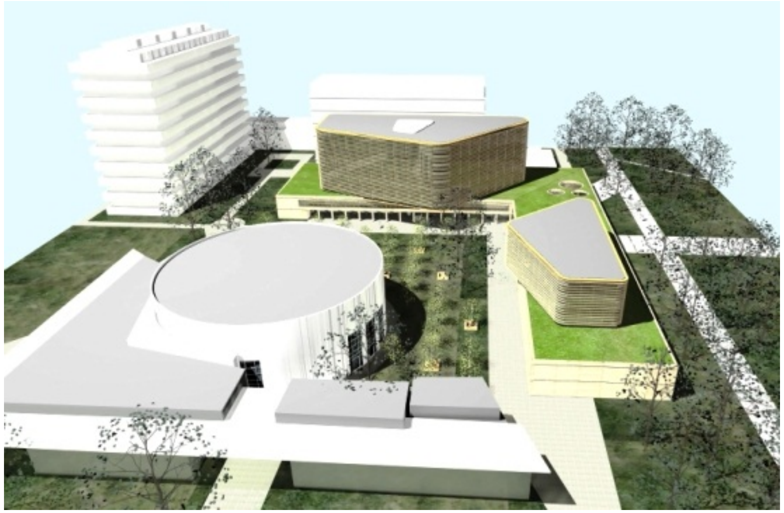
MIKROTRIBOLOGIE CENTRUM - Numbers

-8 groups, 80 employees, 20 doctoral students, 4 professors
-annual turn over 5 Mio. €
-investments between 2008 bis 2015: 20 Mio. €

-good cooperation with KIT and Universität Freiburg
-many national and international collaborations



RNT Test Cells



Analytics

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Structure

MikroTribologie Centrum
Prof. M. Scherge, Prof. P. Gumbsch

Dr. A. Kailer
Wear protection, technical ceramics

Prof. Dr. M. Moseler
Multiscale modelling and tribosimulation

Dr. R. Jaeger
Polymer tribology and biomed. materials

B. Blug
Tribological coatings

Prof. Dr. M. Dienwiebel
Applied nanotribology

Karlsruhe Institute of Technology

Dr. C. Greiner
Dynamics of sliding metal interfaces

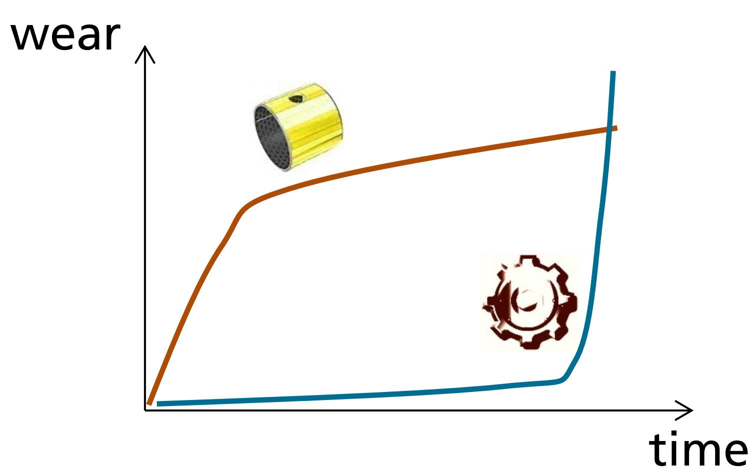
Dr. L. Pastewka
Contact simulation

Dr. J. Schneider
Microtribology

Focus: Systems with Ultra Low Wear Rates

Typical average wear rates of engine components as determined by radionuclide technique [4]

Engine component	Wear-rate
Piston ring	5–15 nm/h
Small conrod bearing	Maximum 8 nm/h
Large conrod bearing	2–10 nm/h
Tappet	10 nm/h
Cam	5–10 nm/h

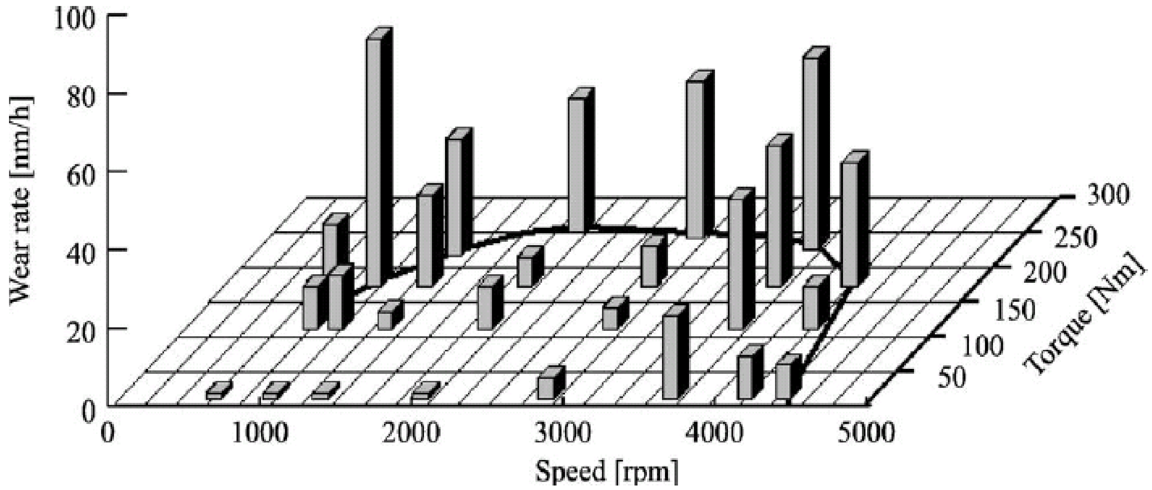


Tribological Levers to Reduce CO_2-Emission and Fuel Consumption

lever	effect
running-in	-direct energetic conditioning of the system
oil and additivation	-direct (additives) and indirect (viscosity) influence on the system
finishing	-partial presumption of the running-in -support of hydrodynamics

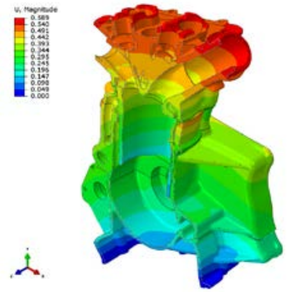
Wear measurement based on the RadioNuclide Technique (RNT)

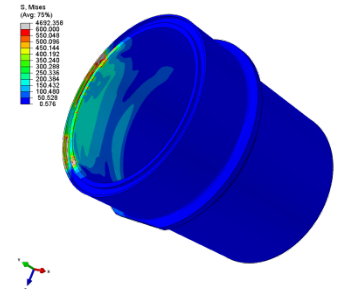
Removal of engine parts (e.g. piston ring or bearing) → Radioactive labeling and re-assembling → Continuous wear measurement

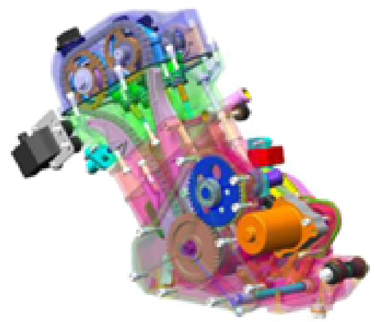


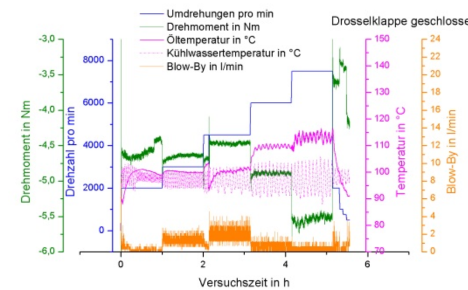
M. Scherge, K. Pöhlmann, A. Gervé, Wear Measurement using Radio-Nuclide-Technique (RNT), *Wear*, **254**(2003), 801-818

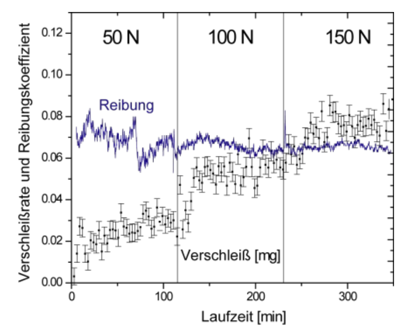
Single Engine Test Cell with RNT











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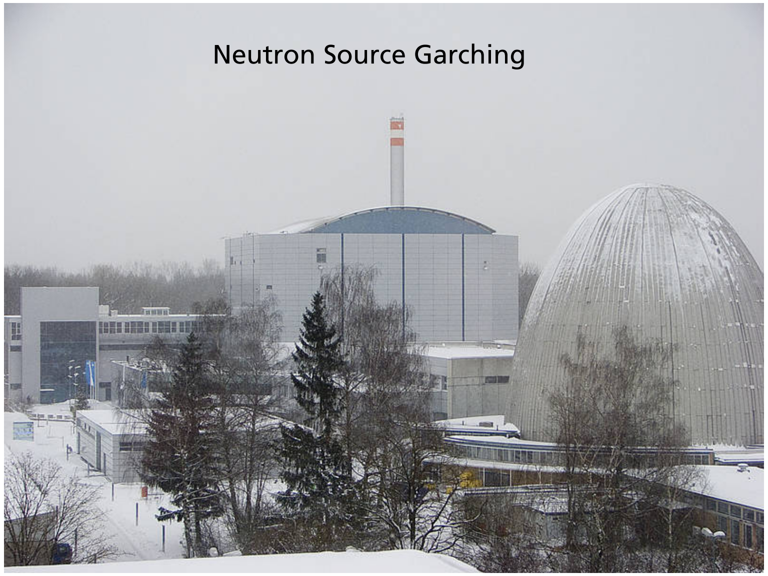
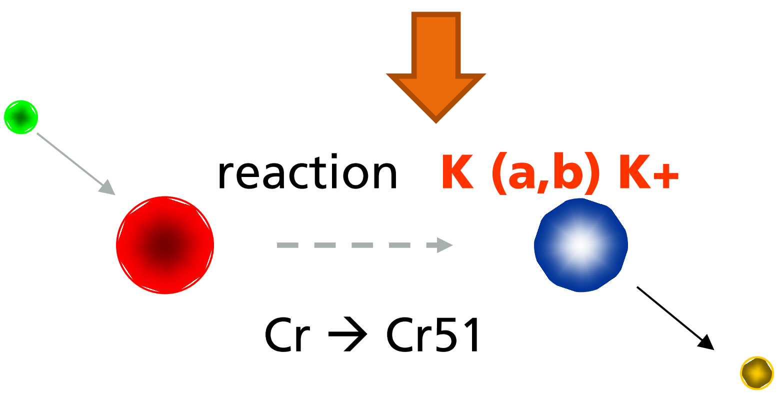
Labeling

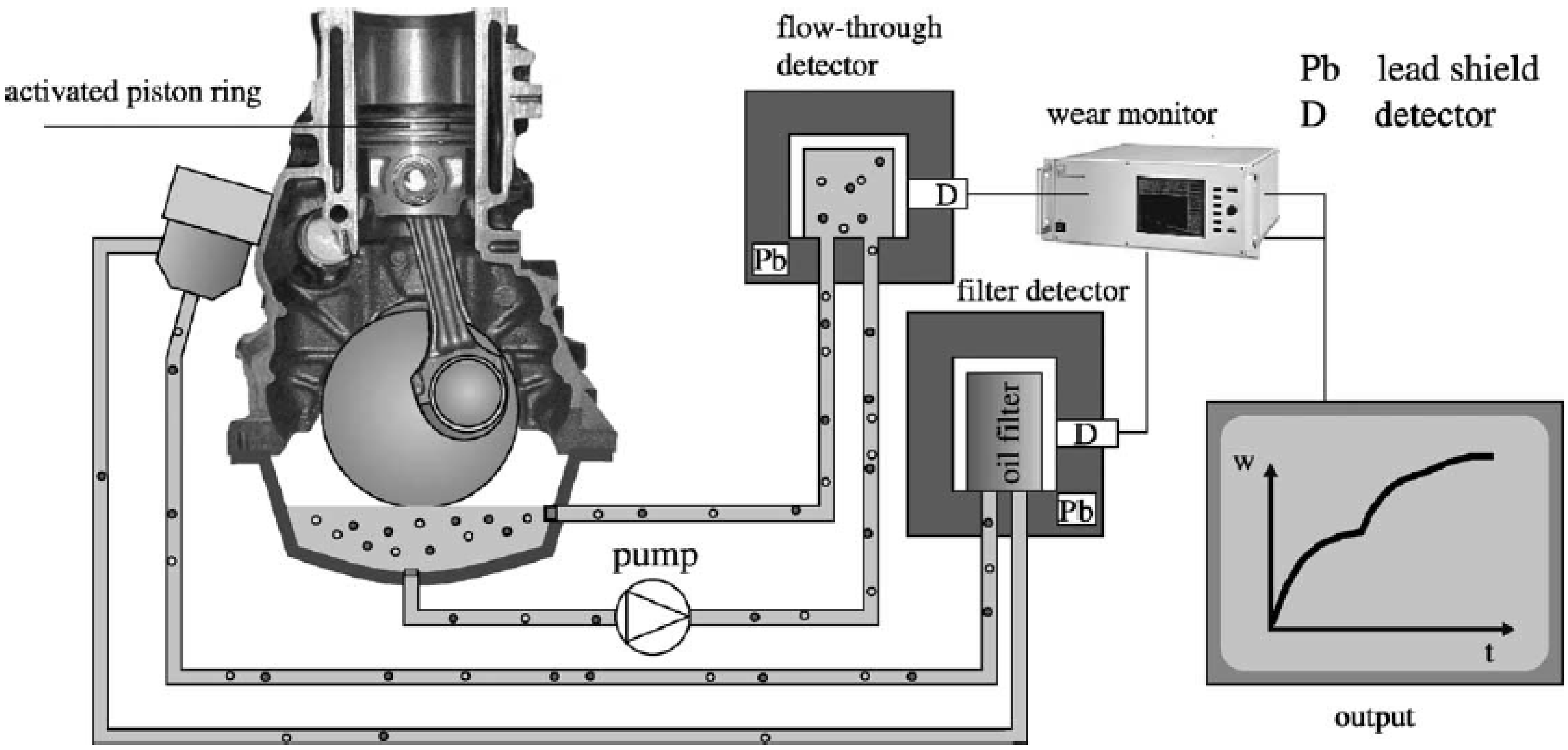


thermal neutrons



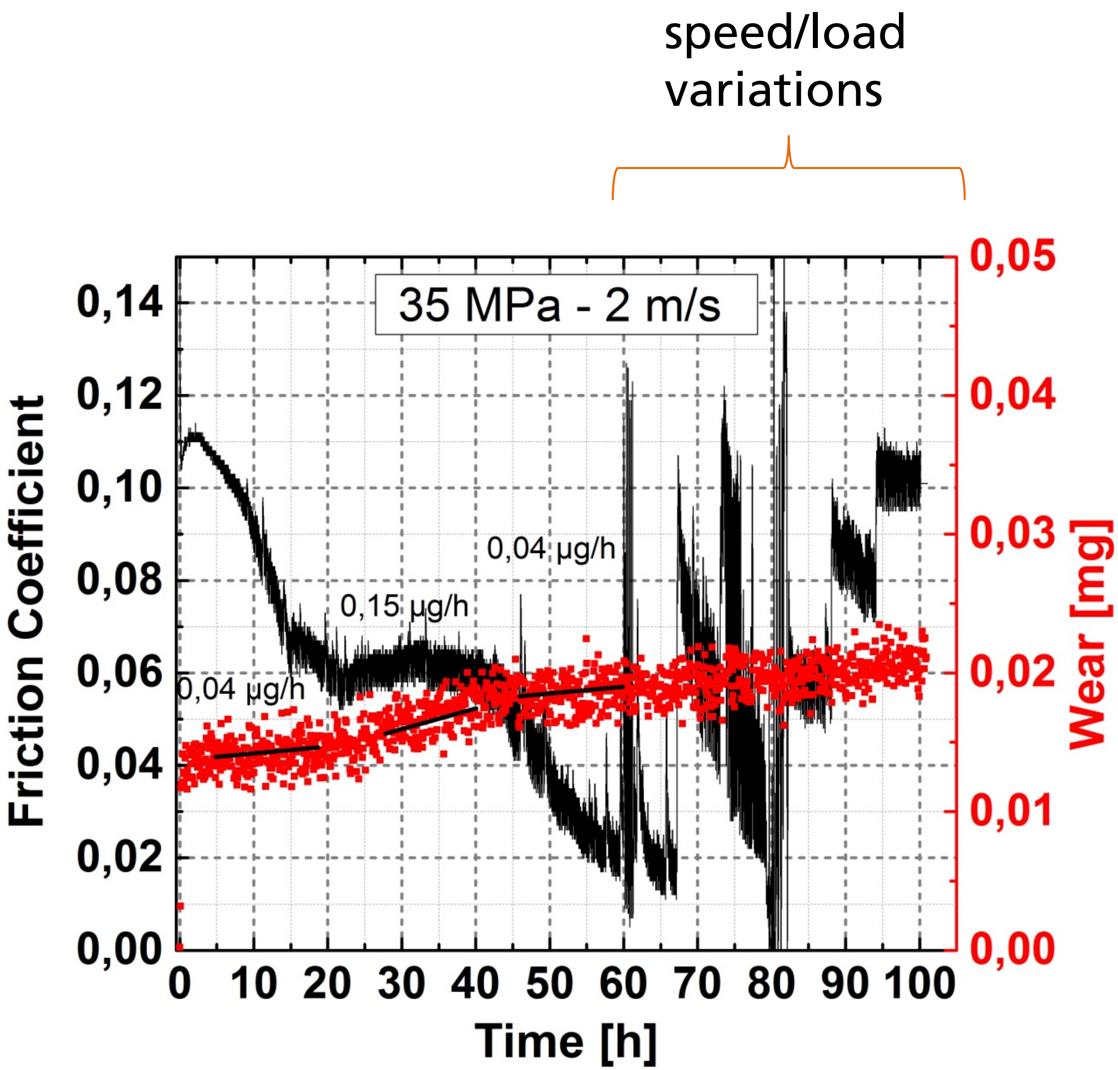
pneumatic delivery

Test Setup

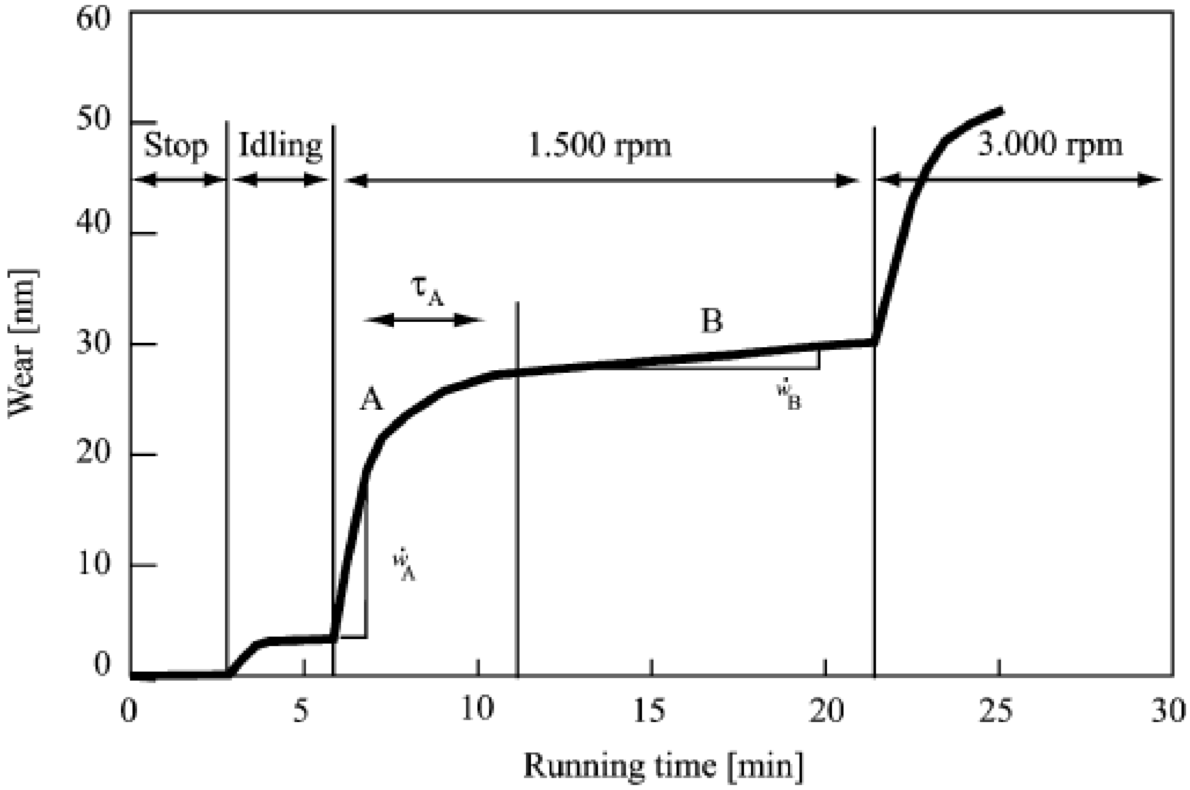


M. Scherge, K. Pöhlmann, A. Gervé, Wear Measurement using Radio-Nuclide-Technique (RNT), *Wear*, **254**(2003), 801-818

Precise and Online Friction and Wear Testing

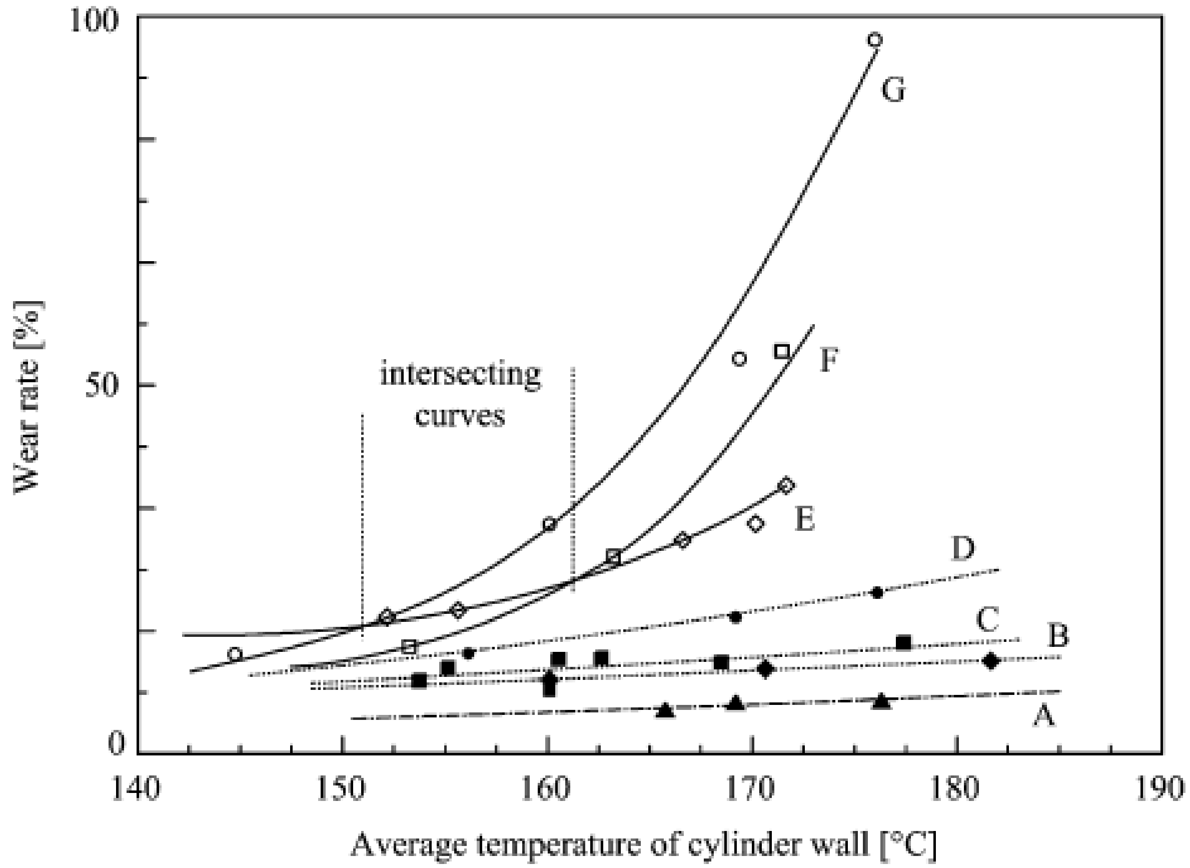


Analysis of Running-in Wear



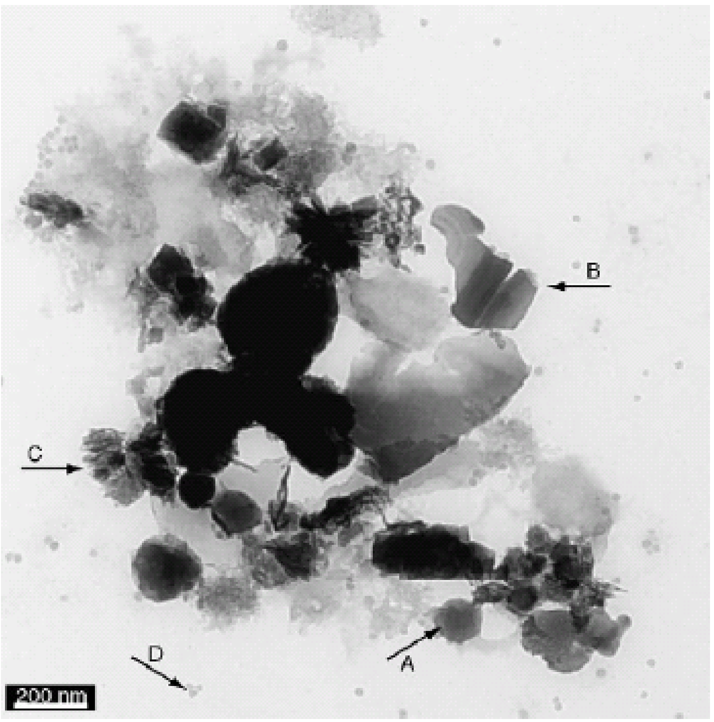
M. Scherge, K. Pöhlmann, A. Gervé, Wear Measurement using Radio-Nuclide-Technique (RNT), *Wear*, **254**(2003), 801-818

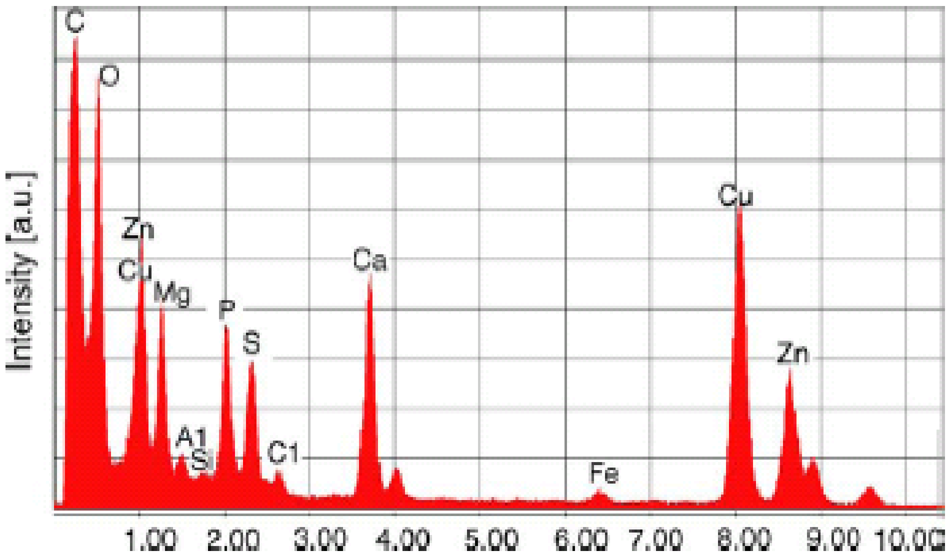
Oil Testing by RNT



M. Scherge, K. Pöhlmann, A. Gervé, Wear Measurement using Radio-Nuclide-Technique (RNT), *Wear*, **254**(2003), 801-818

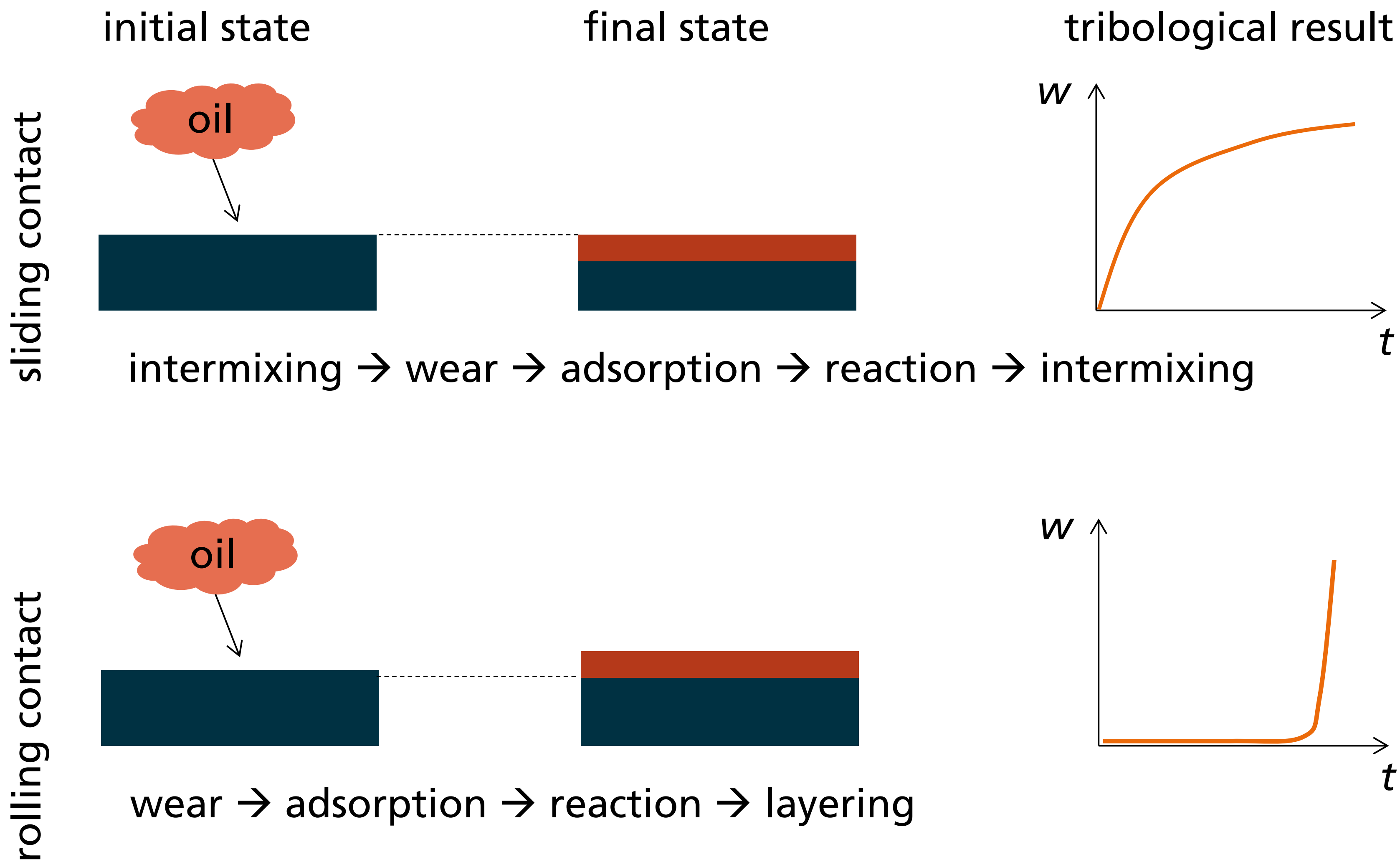
Analysis of Engine Wear Particles



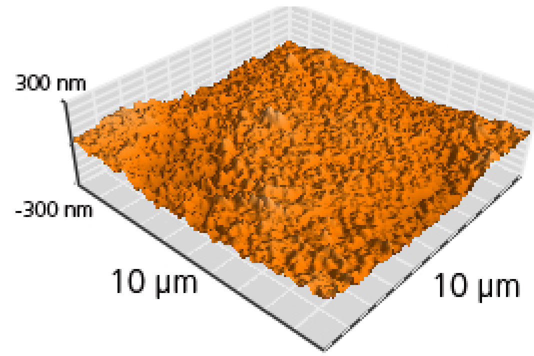


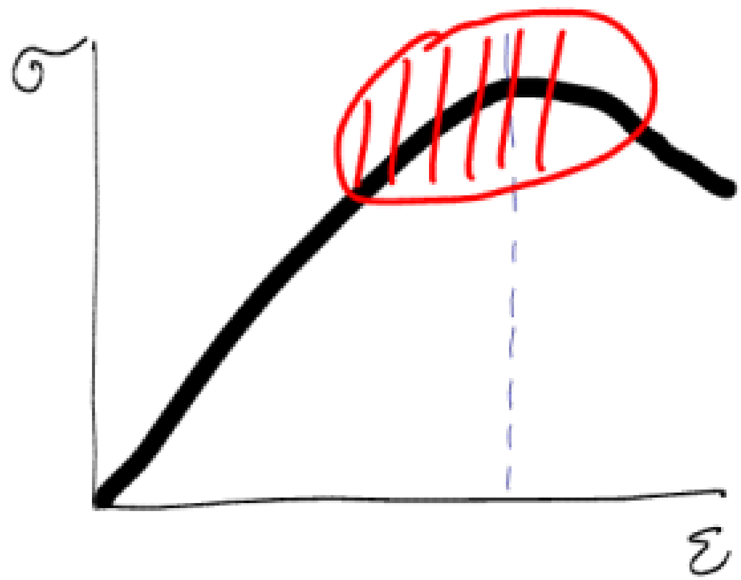
Source: Characterization of wear debris of systems operated under low wear-rate conditions, Scherge et al., WEAR 260(2006)458-461.

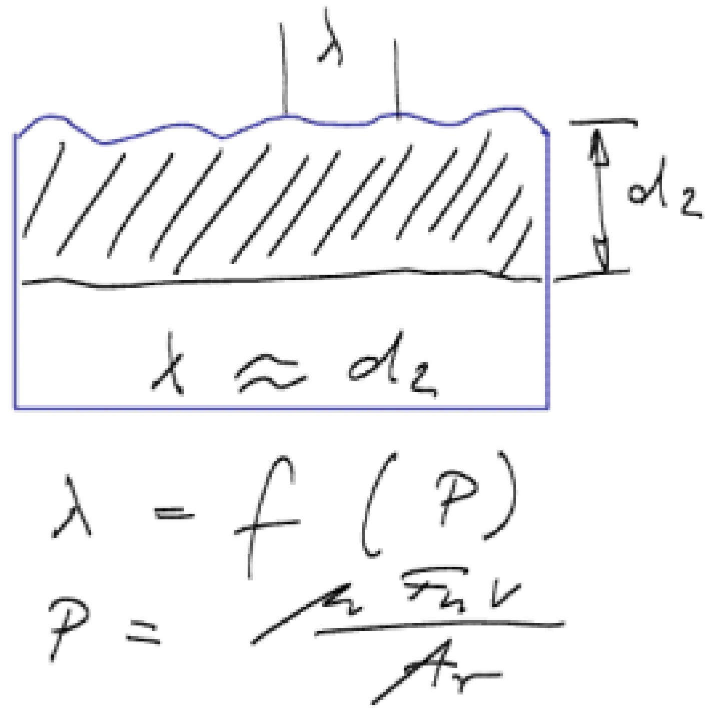
Oil – Surface Interaction



Elastic and Plastic Deformations







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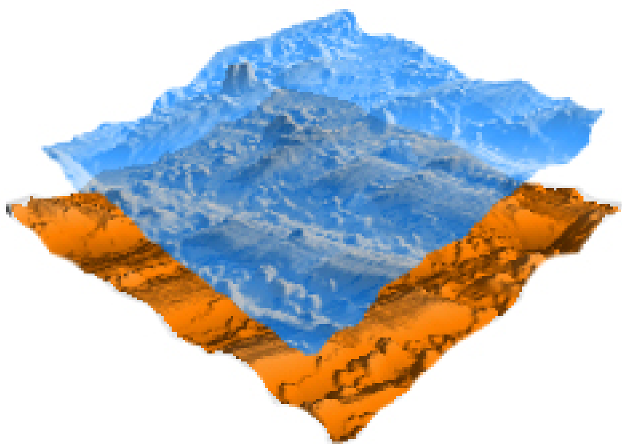
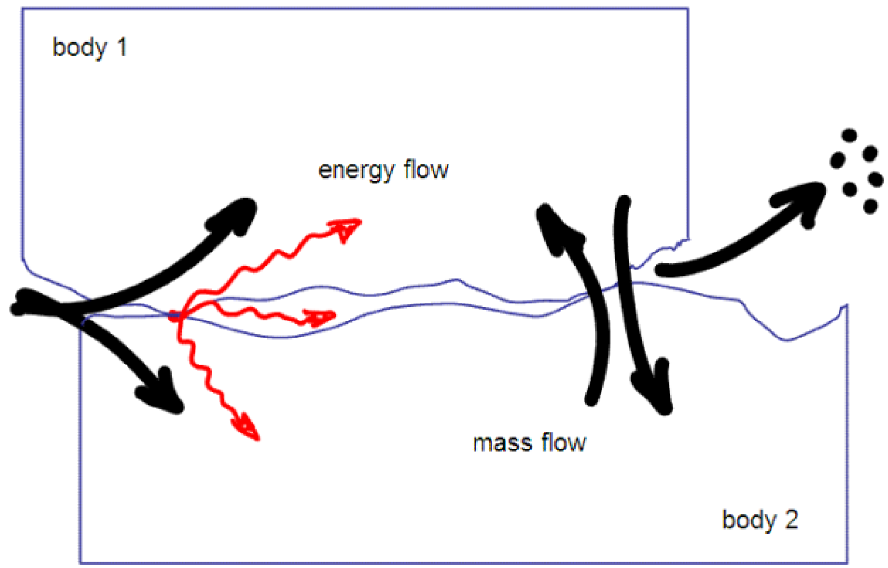
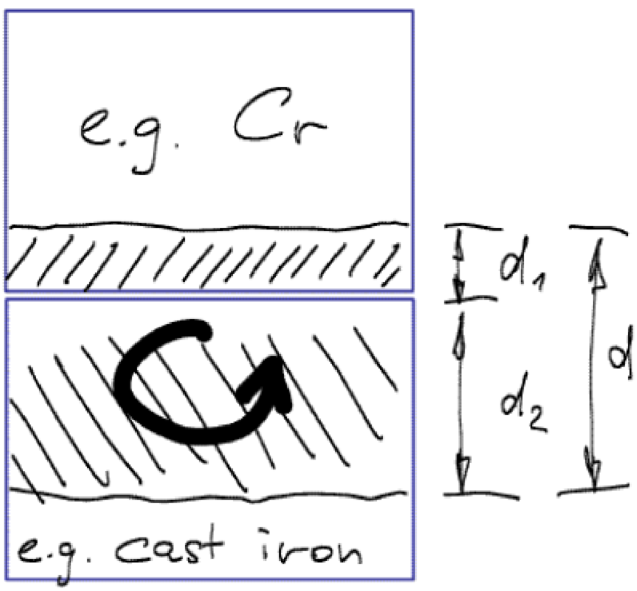
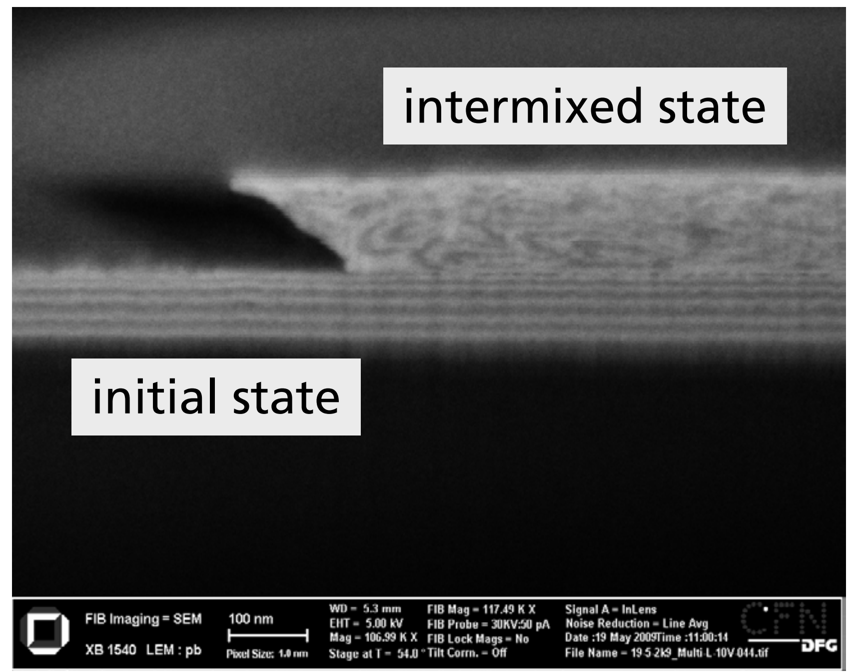
Interacting Bodies with Lubrication





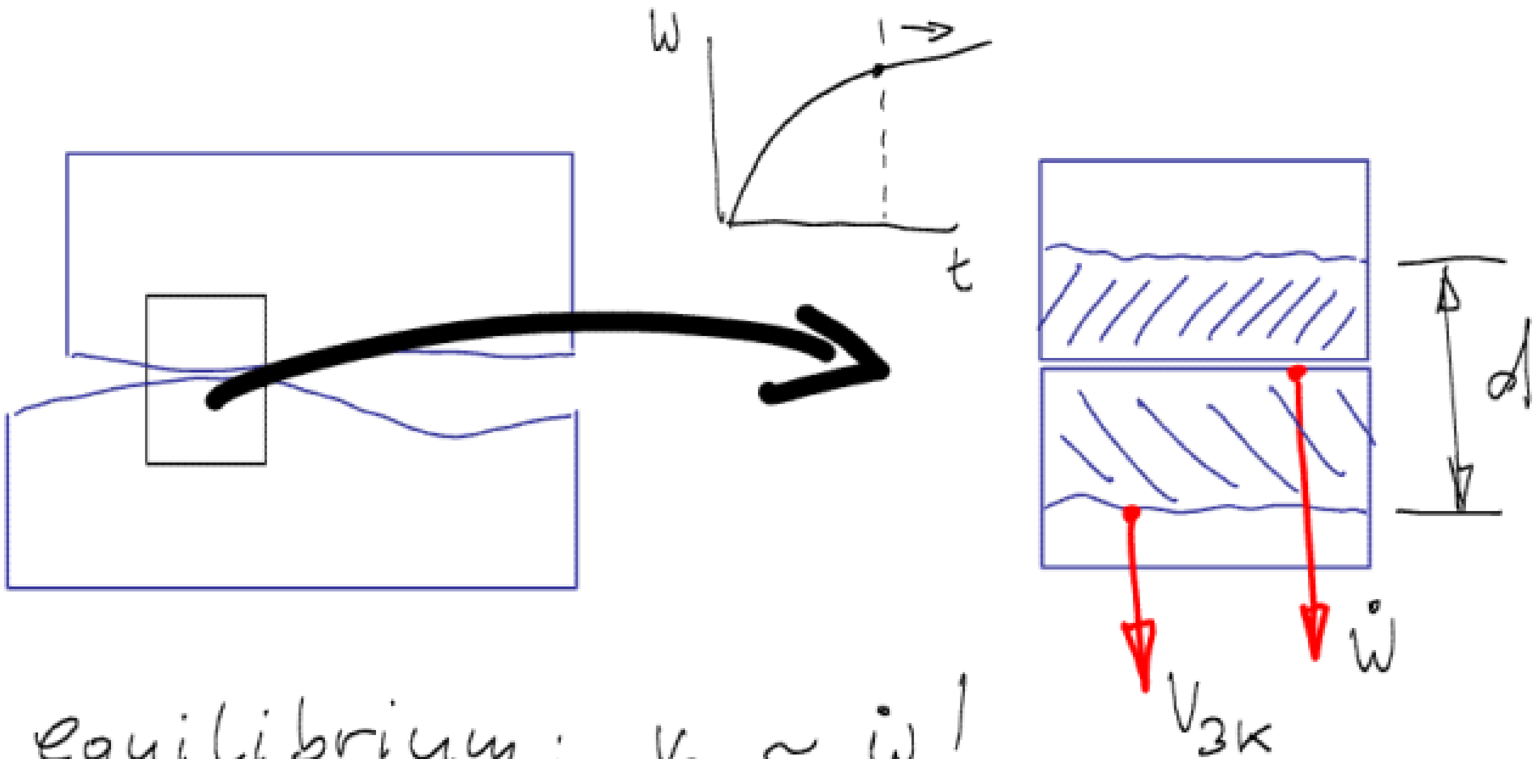
Intermixing





$d = \text{const.}$

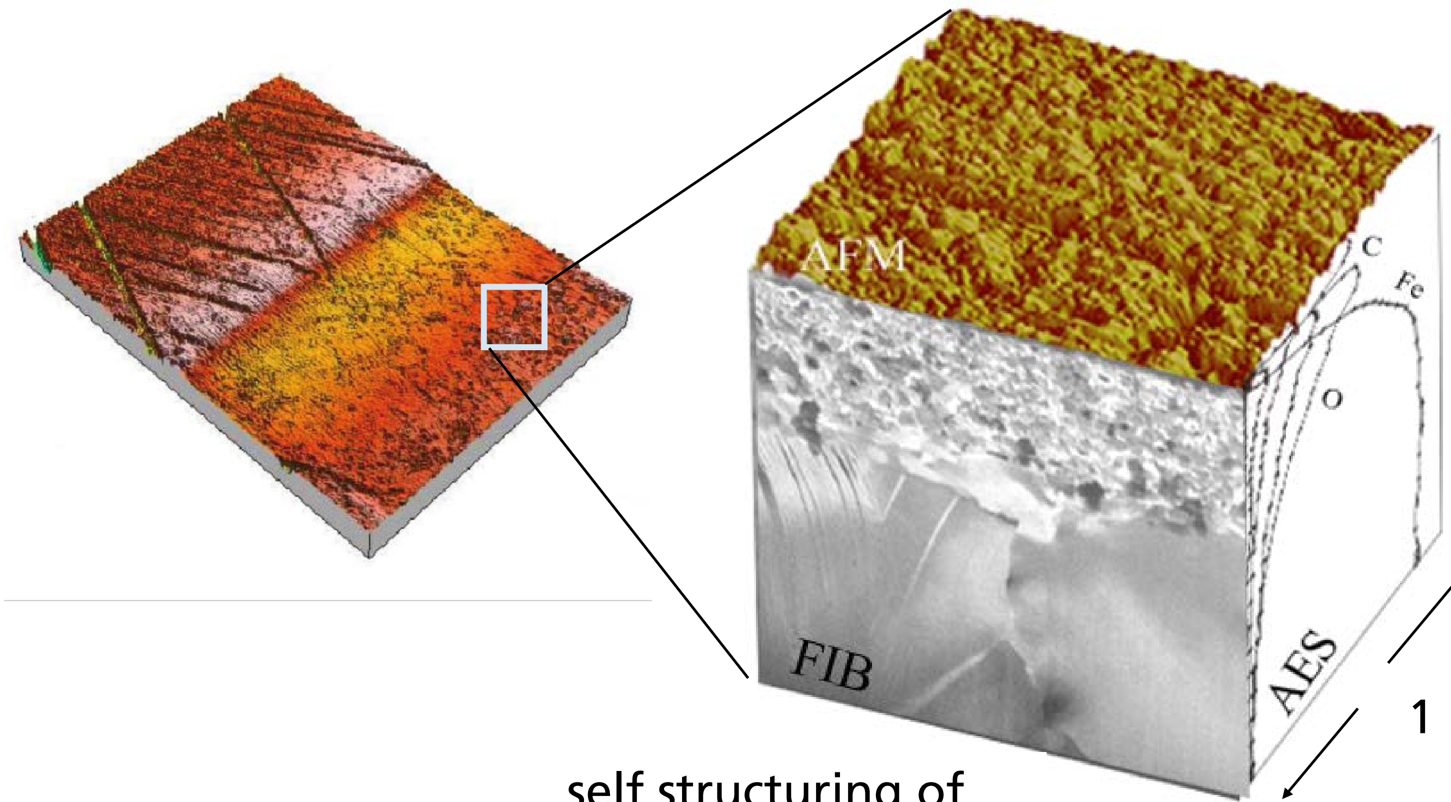
Tribosystem in Equilibrium



equilibrium: $V_{3k} \approx \dot{w}$!

Material Changes during Running-in

self structuring of surface

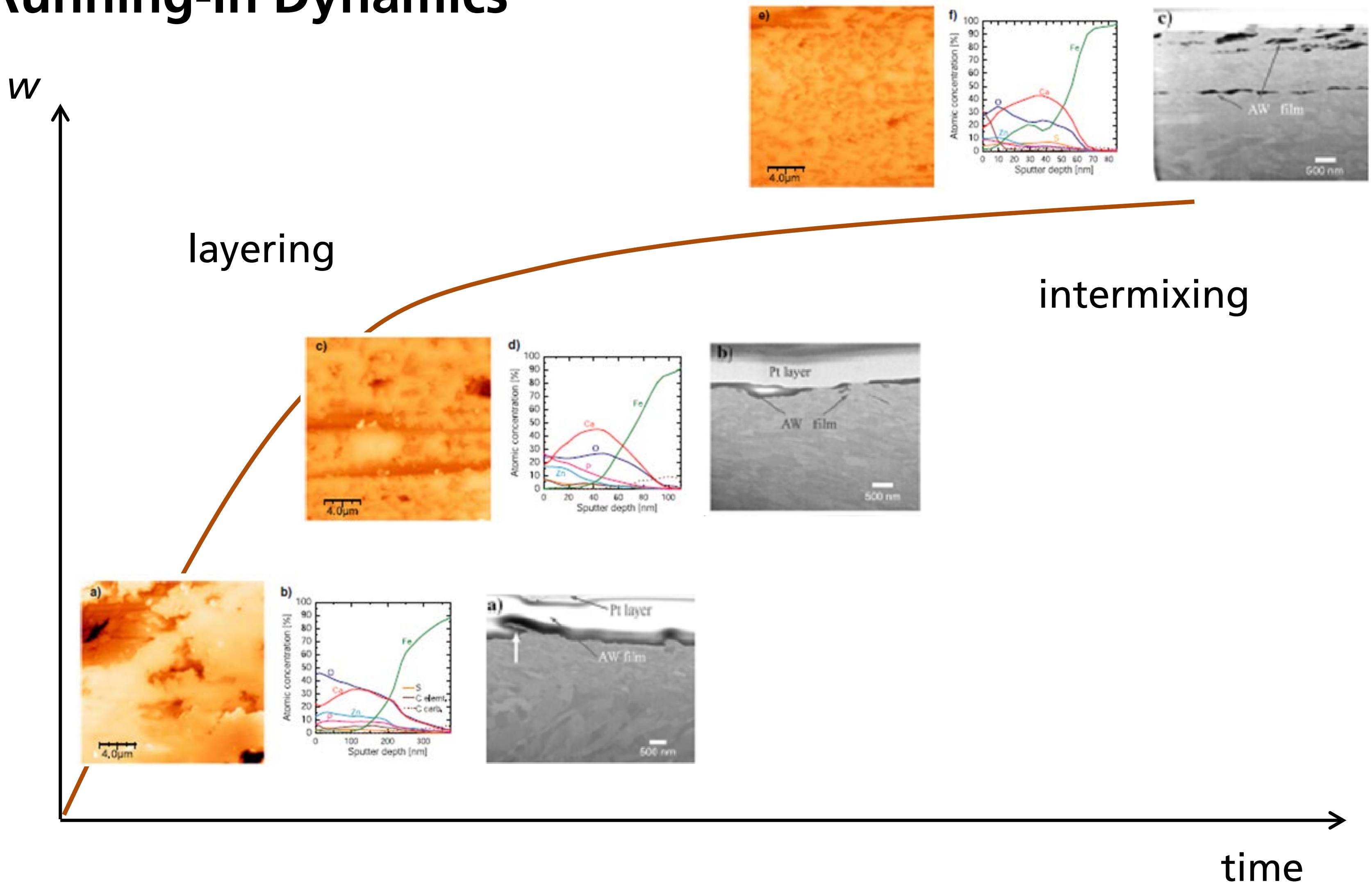


tribochemical effects

1 µm

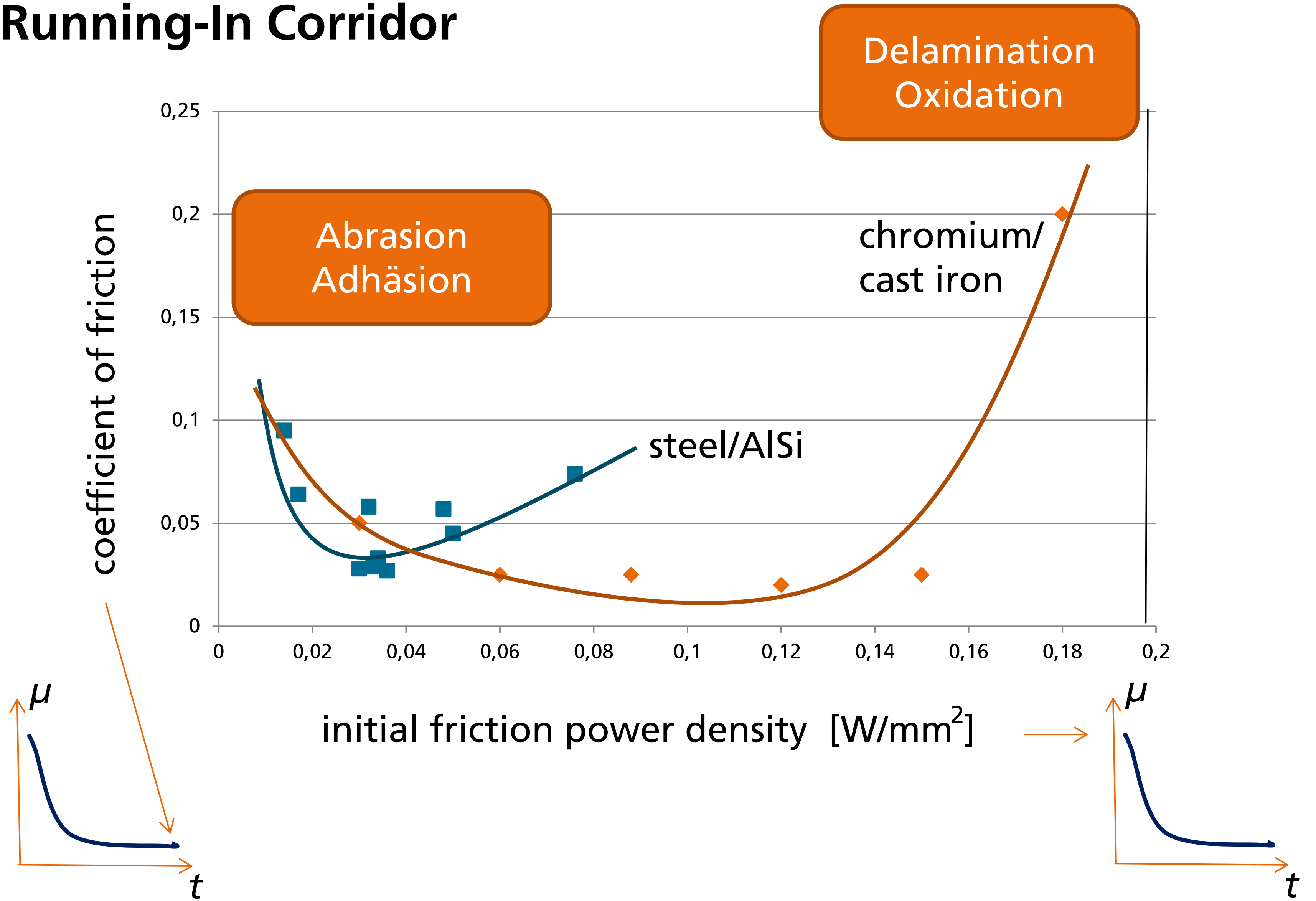
self structuring of near-surface volume

Running-In Dynamics



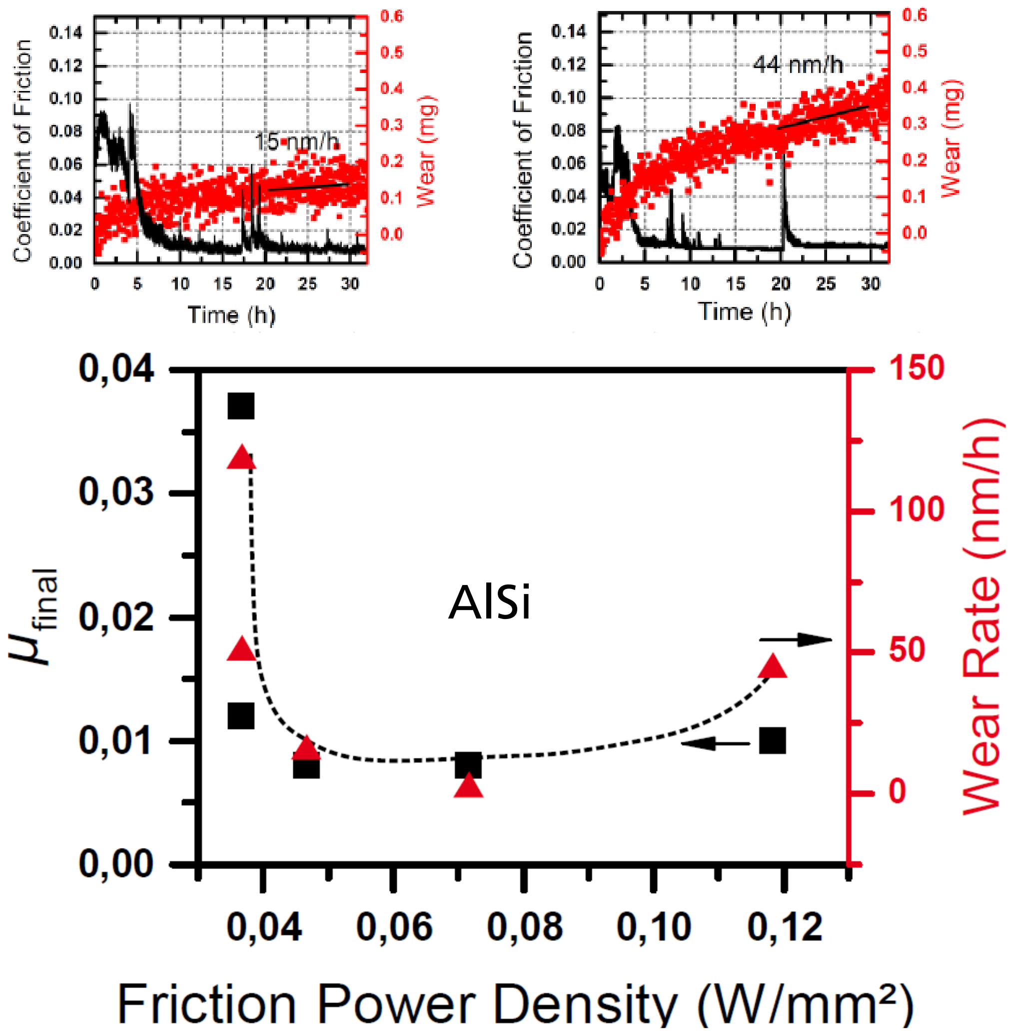
Dienwiebel, Pöhlmann, TRIB. LETT. 27(2007)

Running-In Corridor



M. Scherge, D. Linsler
Wear Corridor, accepted by WEAR

Running-In Corridor – Friction and Wear



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Wear Corridor, accepted by WEAR

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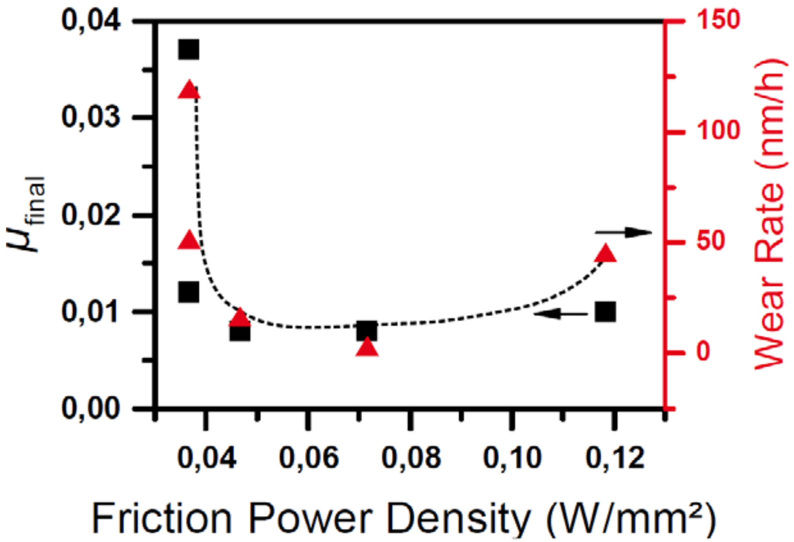
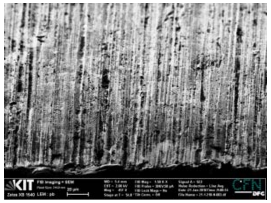
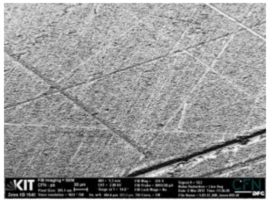
Running-In Recipies

friction power density too high
→ friction modifier
→ increase in real area of contact
→ increase of oil viscosity
→ coatings





increase in real contact area



friction power density too low
→ additivation
→ decrease in real area of contact
→ decrease of oil viscosity

Summary

-the running-in is one of the least understood phenomena of a tribological system

-running-in is controlled by the initial energy consumption of the system

-continuous friction AND wear measurement is the only way to understand the mechanisms

-the tests have to accompanied by high-resolution surface science

-running-in can be influenced by suface finish, oil viscosity and additivation