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In situ Topography Measurement in Tribological Contacts

Timothy Kamps

Workshop on multifunctional ultrafast microprobes for on-the-machine measurements, 19th EUSPEN conference.

Bilbao 3rd June 2019

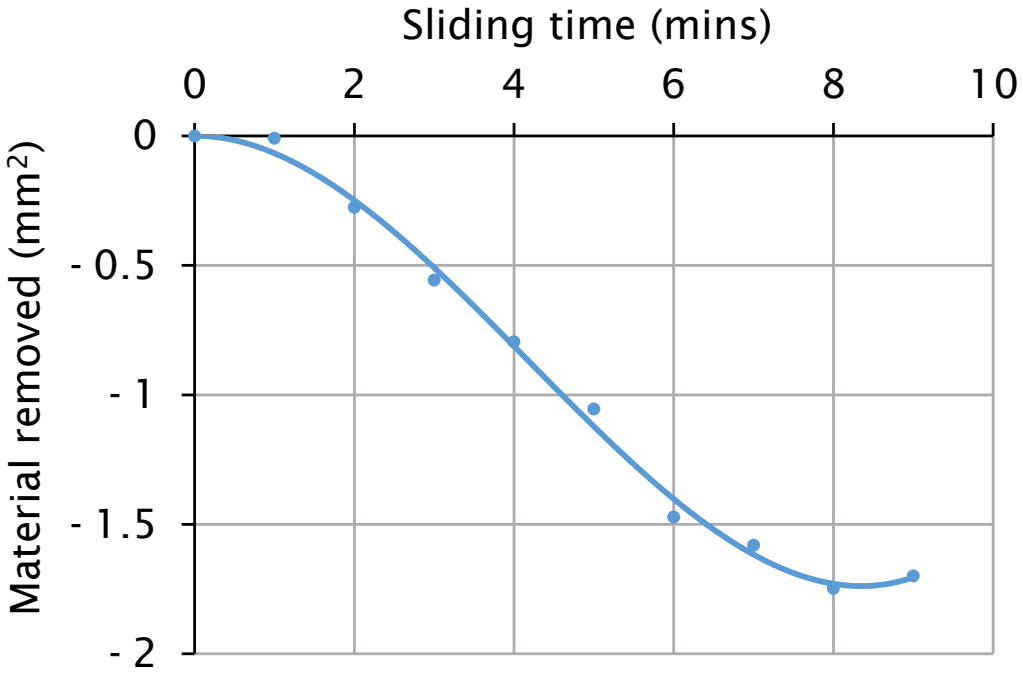
Overview

- Motivation for in situ measurements in tribology
- Specific tribology ‘challenge’
- Development of an in situ tactile profilometer for a benchtop reciprocating tribometer
- Application of an in situ online optical profilometer to a benchtop rotary tribometer

Motivation

- Characterise the frictional response and wear mechanism(s) of a tribo-contact

- Observe wear mechanism transitions



Methods

- Relocation techniques:
  - It takes a long time: operator time and test interruption
  - Expensive tooling
  - Potential for misalignment
  - Use standalone measurement equipment

- In situ measurements:
  - On-line measurement
  - Off-line measurement (pause test)
  - Samples remain in contact
  - Bespoke product

Development of an in situ tactile profilometer for a benchtop reciprocating tribometer

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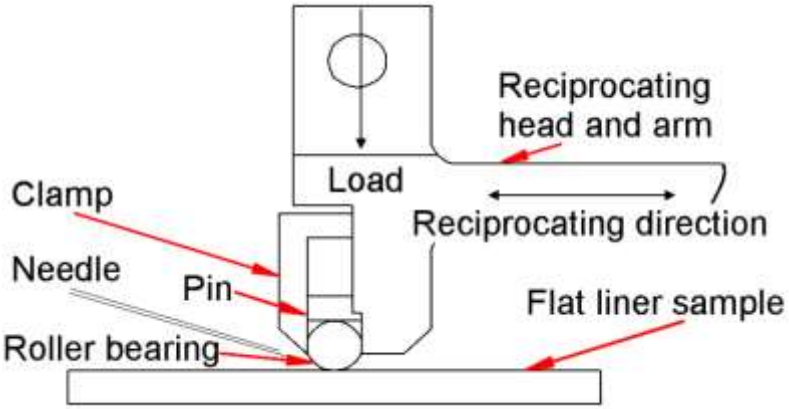
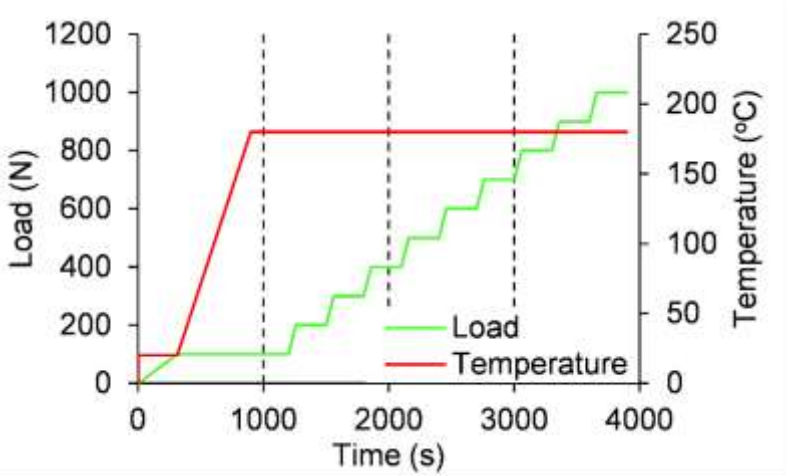
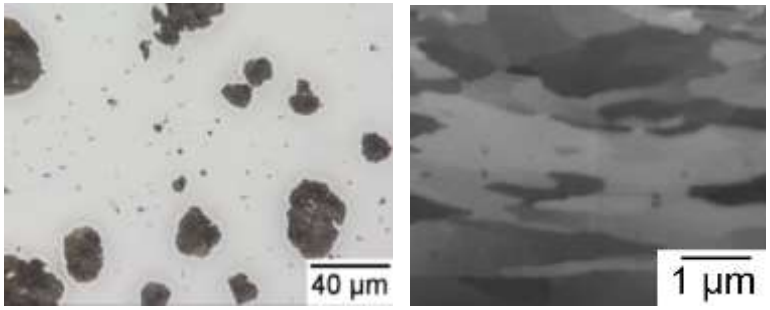
[1] UNIVERSITY OF Southampton

[2] PHOENIX TRIBOLOGY

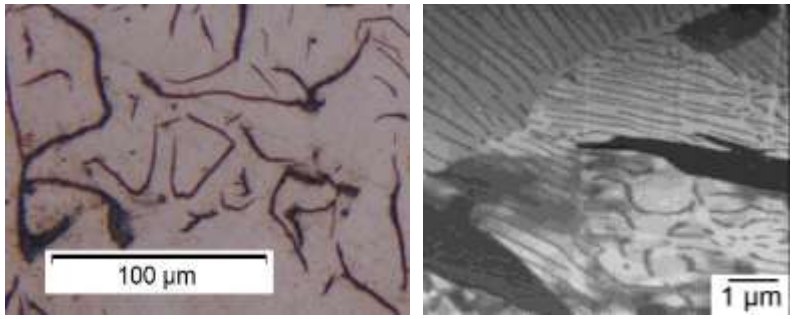
Methodology for investigating Scuffing





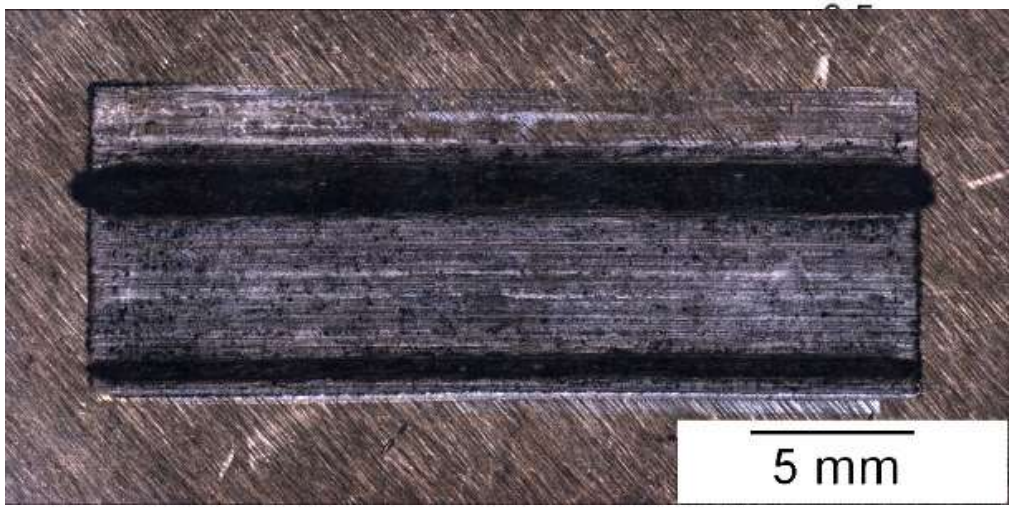


Grade 400-15 nodular graphite ferrite matrix, 172±3 Hv.

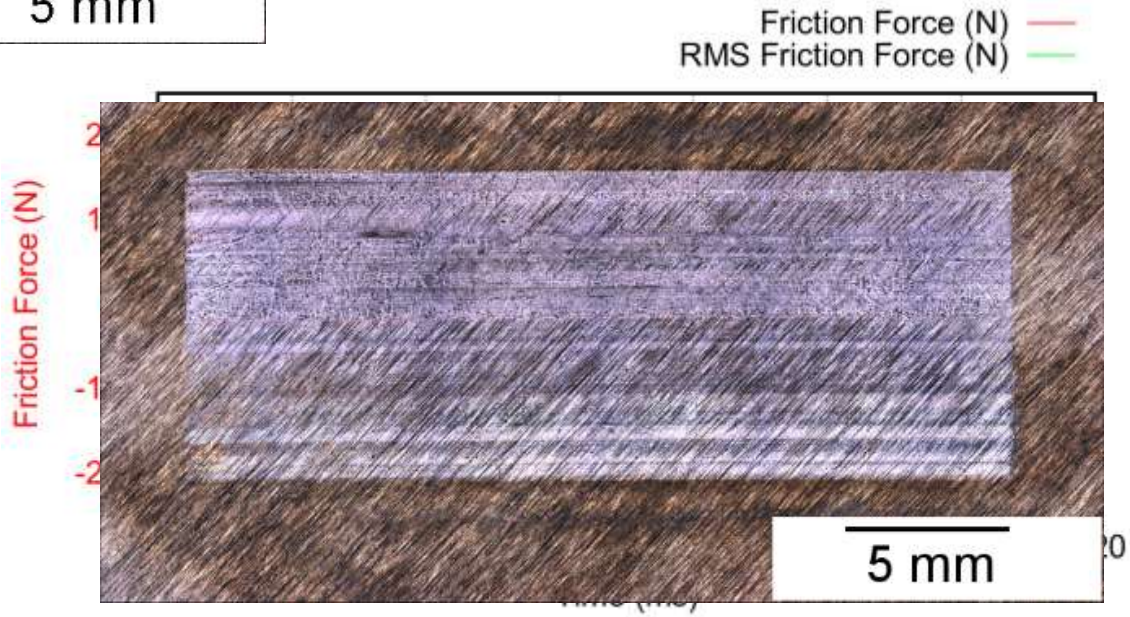


Grade 250 flake graphite pearlite matrix, 209±9 Hv

Scuffing detection techniques



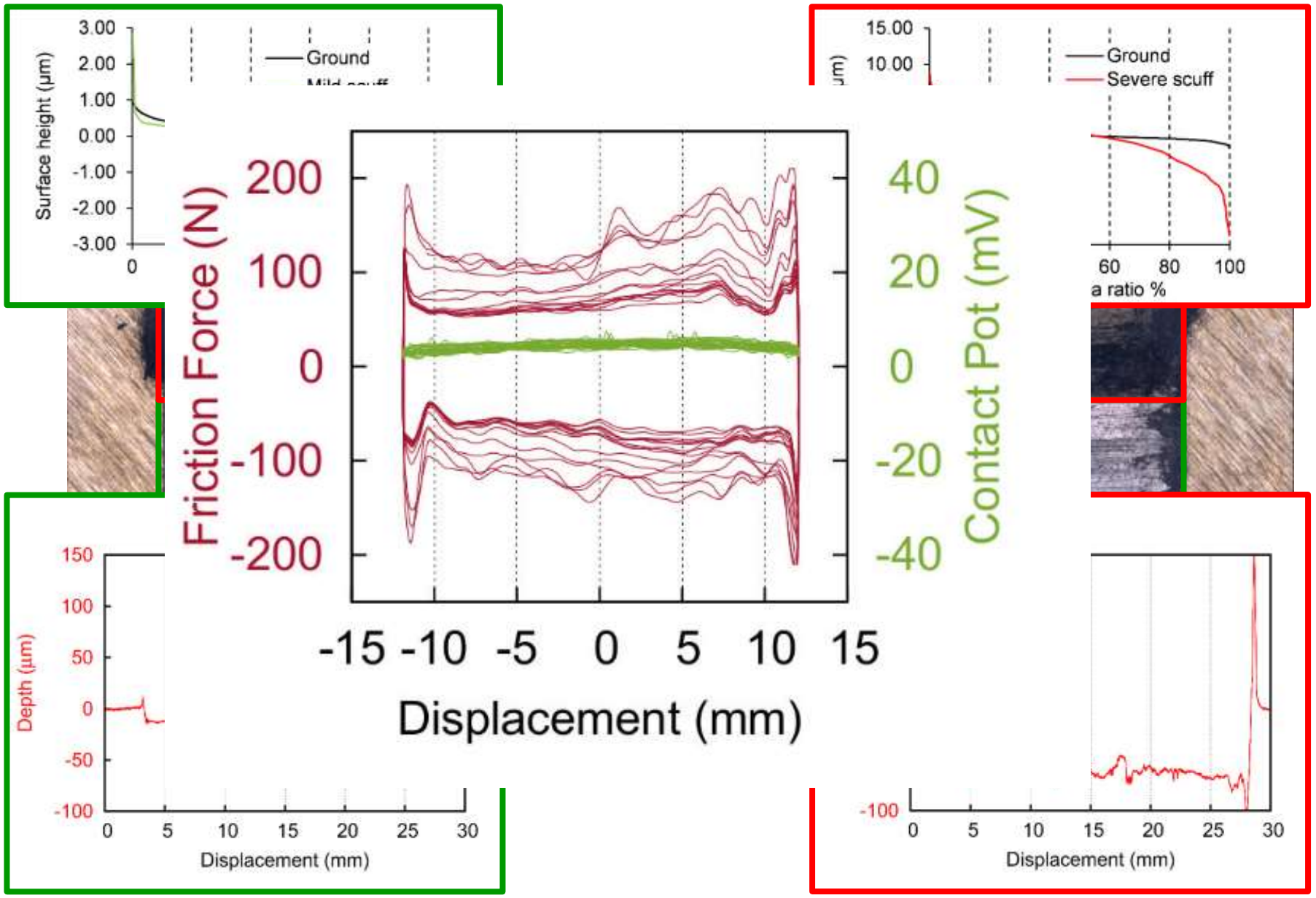
Severe scuffing
Rapid rise in friction coefficient
Sampling frequency 10 Hz



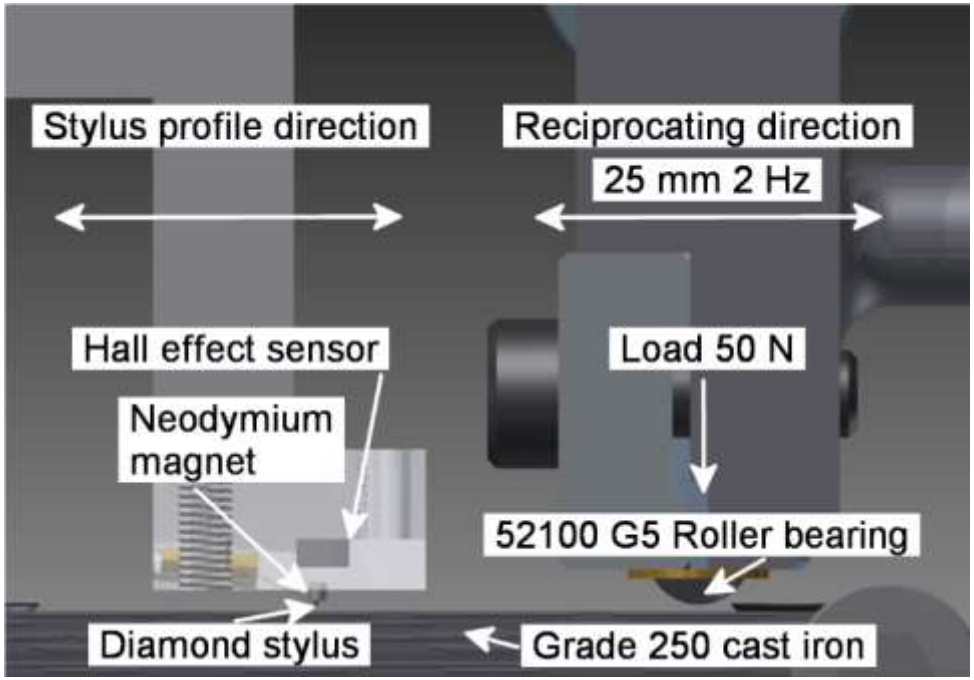
Mild scuffing
local increases in friction force associated with adhesive wear.
Sampling frequency 10 kHz

Kamps, T. J., Walker, J. C., Wood, R. J., Lee, P. M., & Plint, A. G. (2015). Reproducing automotive engine scuffing using a lubricated reciprocating contact. Wear, 332–333, 1193–1199.

Scuffing topography evolution

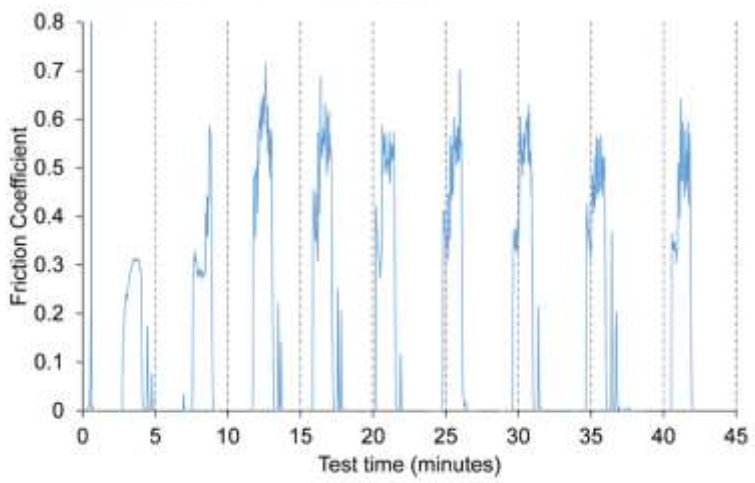


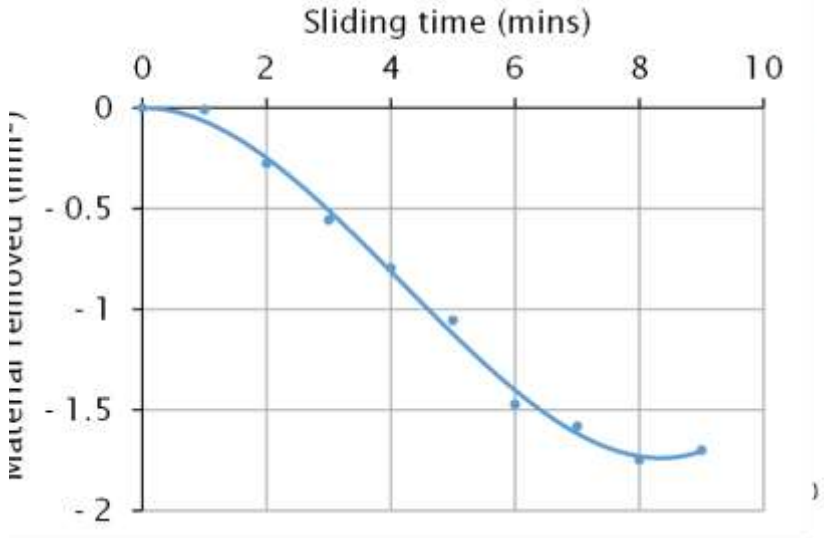
Prototype In situ profilometer

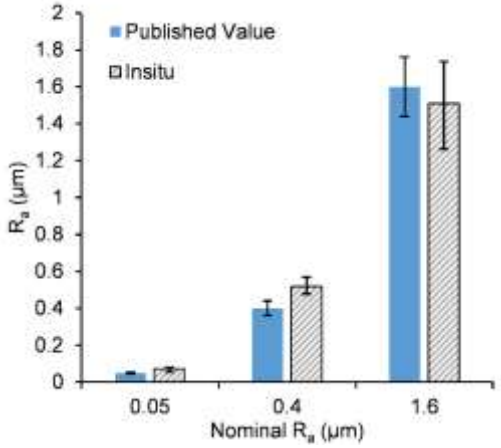


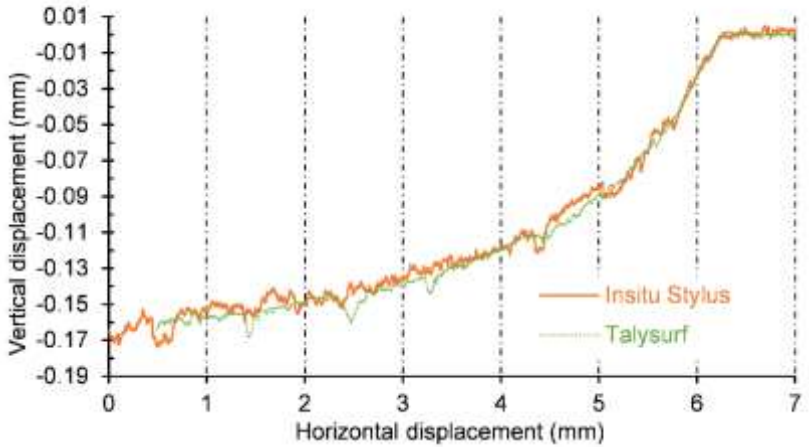
Kamps, T. J., Walker, J. C., & Plint, A. G. (2017). In situ stylus profilometer for a high frequency reciprocating tribometer. Surface Topography: Metrology and Properties, 5(3), 034004. https://doi.org/10.1088/2051-672X/aa7da8

Dry sliding steel roller against cast iron









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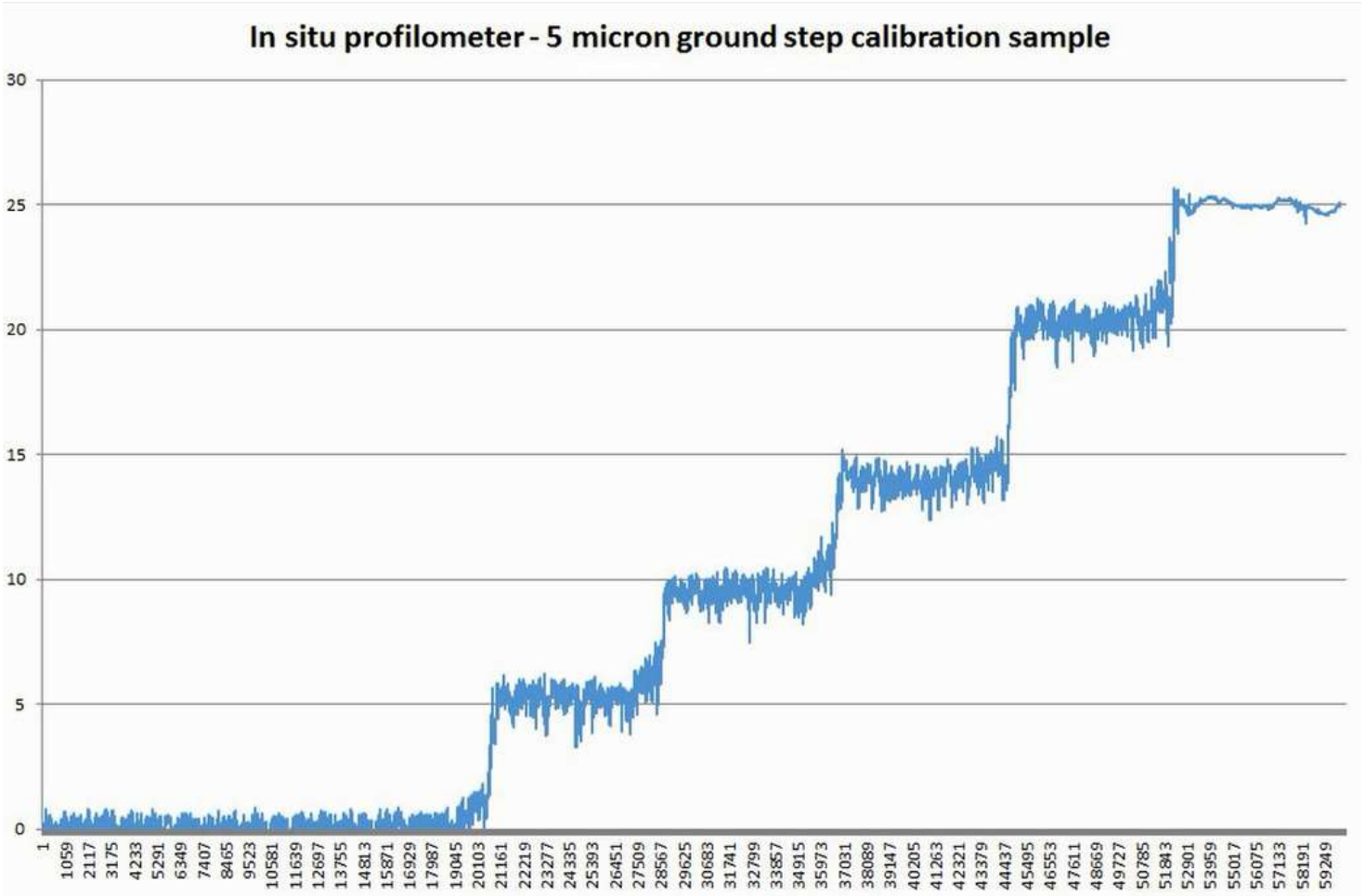
Phoenix Tribology:
TE-77 In situ profilometer



PLINT Tribology Products
from Phoenix Tribology Ltd

Methods

- Relocation techniques:
  - It takes a long time: operator time and test interruption
  - Expensive tooling
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  - Use standalone measurement equipment

- In situ measurements:
  - On-line measurement
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Application of an in situ online optical profilometer to a benchtop rotary tribometer

Timothy Kamps, Mark Gee, John Nunn and Christopher Jones

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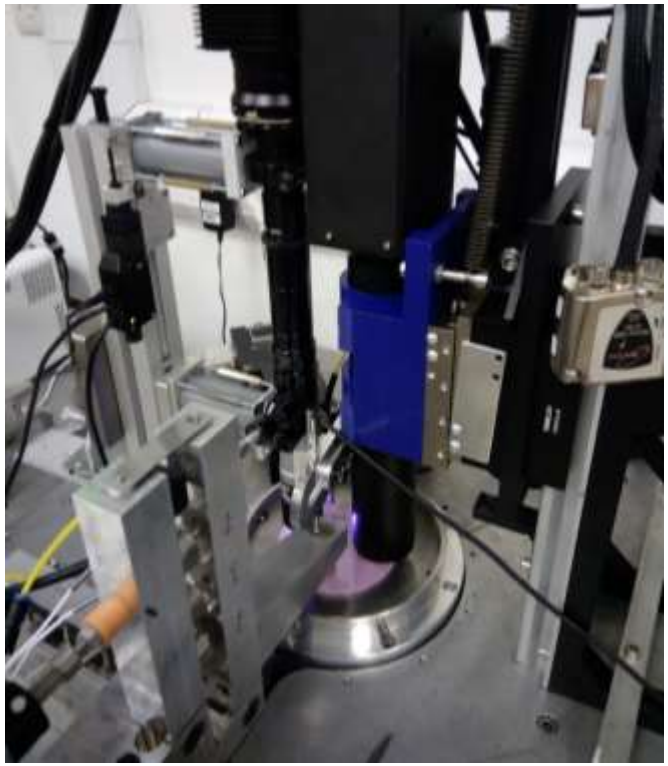
NPL Integrated Tribometer

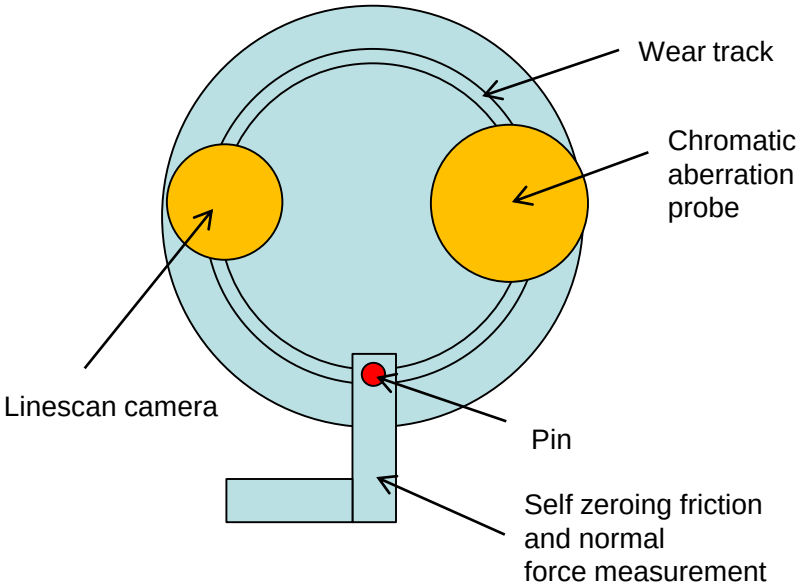
- Pin-on-disc system
- Loaded through lever system below machine table or actuator system
- Allows unrestricted access for multiple sensors
- Current focus on linescan camera for visual imaging and multipoint chromatic aberration probe for real time profilometry



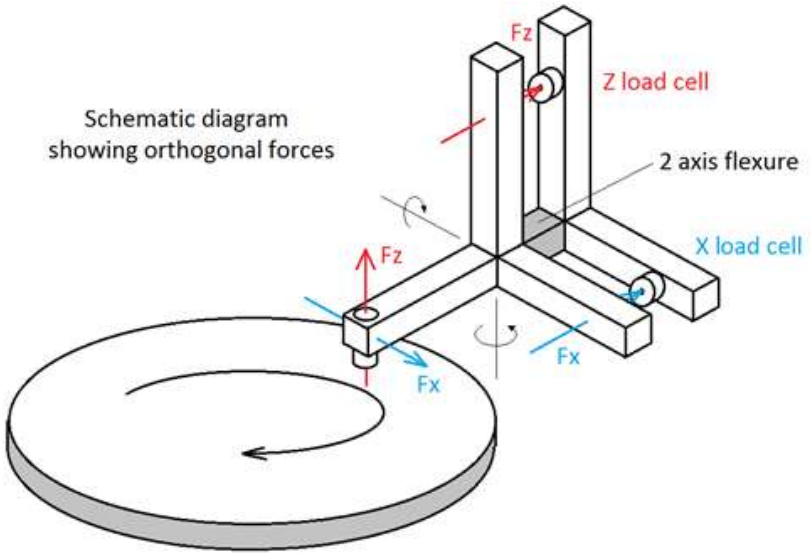
Overall view

Close up

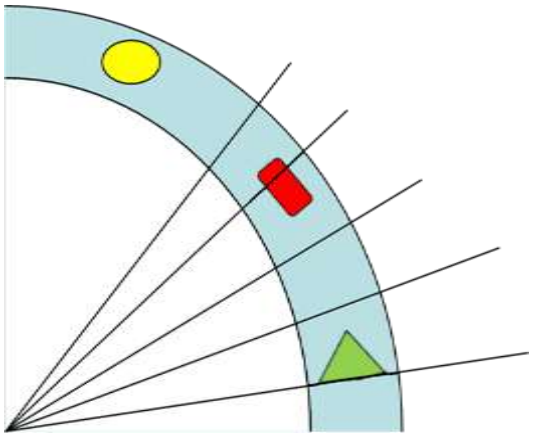
Schematic of Layout



Top view of layout

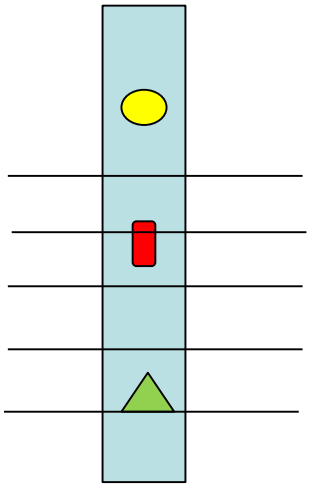


Schematic of self zeroing friction device



Scanning through rotation of disc

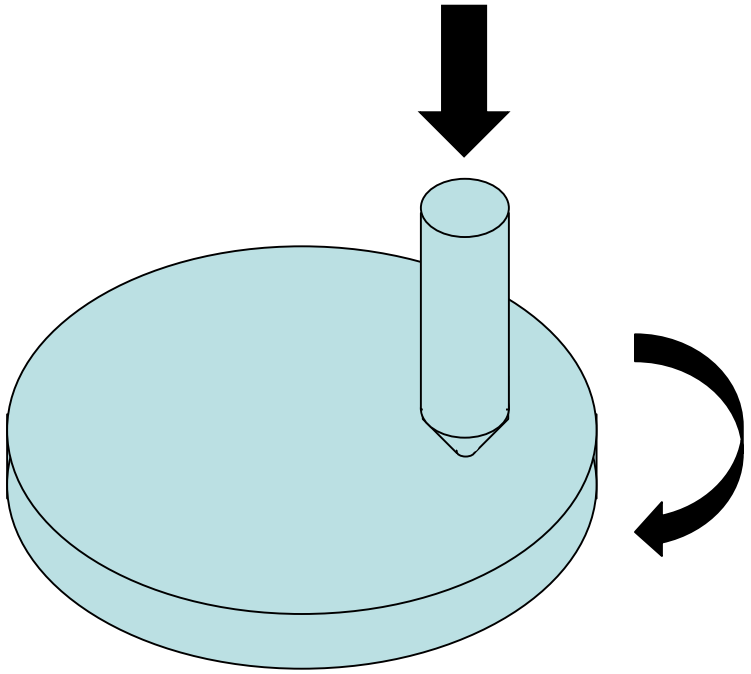
4 images per revolution
Interval for capture selected by user



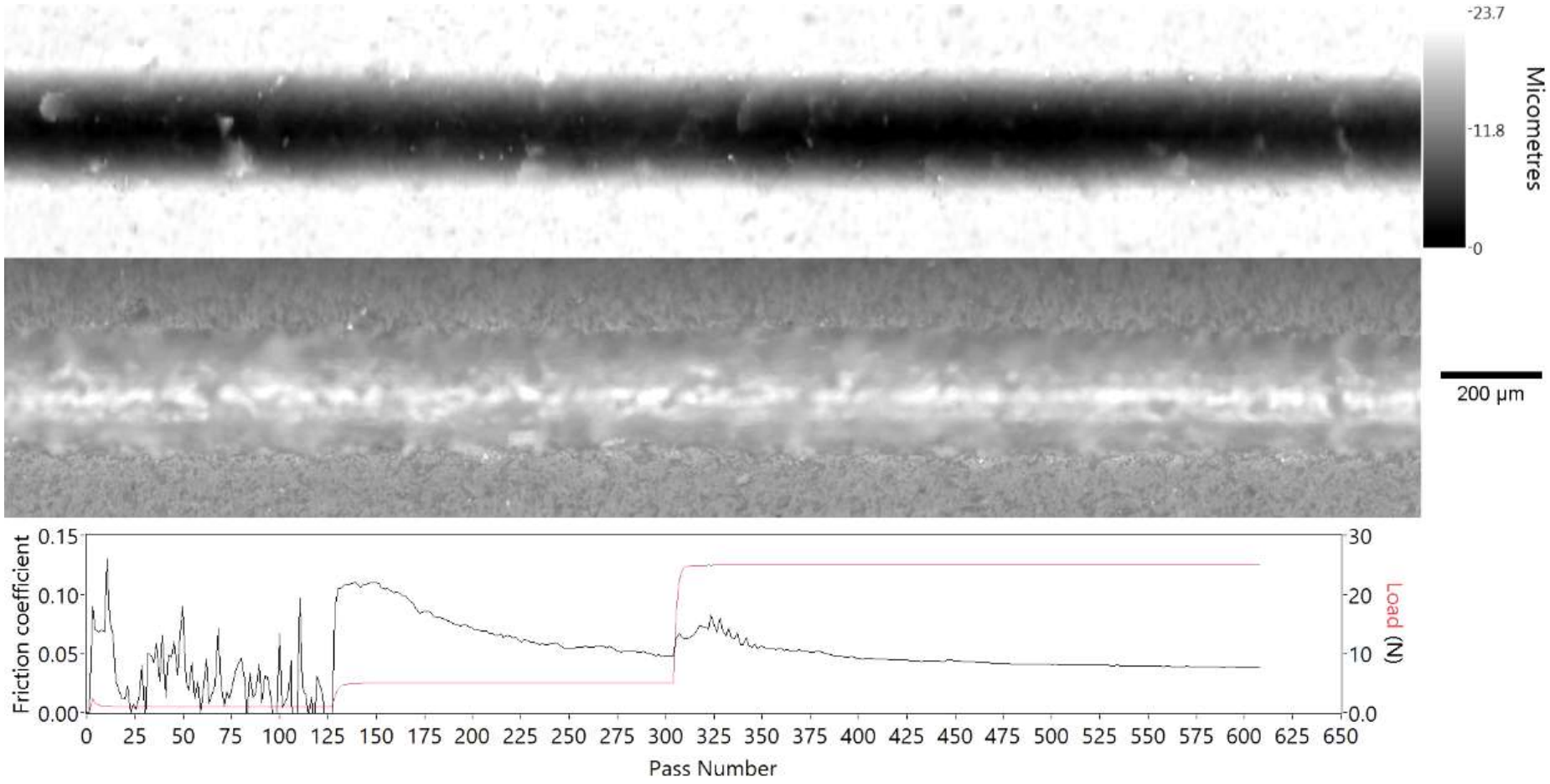
Final image

Rotating Scratch Test

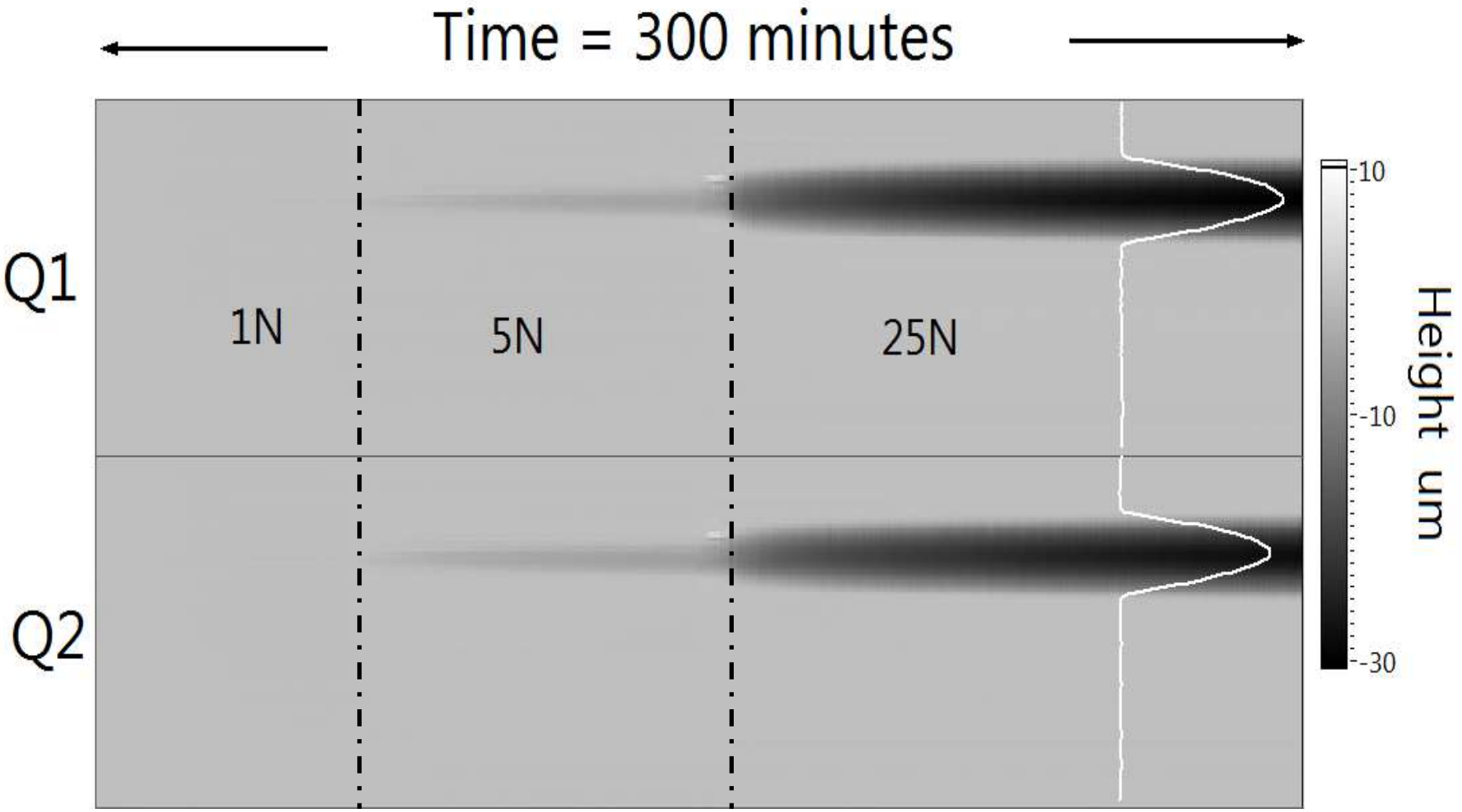
- Like linear scratch test with 200 µm radius diamond indenter
- Alumina disk
- Continuous rotation
- Allows real time examination of build-up of damage
- Parallel monitoring of friction



Rotating Scratch Test



Wear scar evolution



Summary

- In situ profilometry enables the correlation of wear mechanism transitions with friction measurement.
- On-line and Off-line techniques advance current best practice method of re-location.
- In situ profilometry is high value for tribologists as it reduces the number of experiments and samples required to study a wear mechanism transition.
- Future work: Application of microprobes presented to both rotary and reciprocating tribometers.

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