Finding The Best Qualitative And Quantitative Assessment Method For Highly Polished Low-friction Surfaces

Janis Lungevics[1,2], Juris Zavickis[1], Liene Pluduma[1], Karlis A Gross[1]

[1] Biomaterials Research Laboratory, Faculty of Materials Science and Applied Chemistry, Riga Technical University (liene.pluduma@rtu.lv)

[2] Institute of Mechanical Engineering, Faculty of Mechanical Engineering, Transport and Aeronautics, Riga Technical University (janis.lungevics@rtu.lv)

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ABSTRACT

A precise surface evaluation method is required to determine the changes on low friction surfaces after exposure to an extreme environment. This study assessed the appearance of highly polished steel with optical microscopy and scanning electron microscopy, but the topography with atomic force microscopy and profilometry. SPIP image metrology software was used to process the AFM and profilometry raw data. Precisely positioned surface indents established a viewing window of coarse and fine surface features within the same area. The results showed that optical microscopy provided the fastest viewing and better-distinguished surface features than scanning electron microscopy. Furthermore, it has the necessary portability for observations in the field. For topographic measurement, there was a limitation on each method, but atomic force microscopy provided the best quantitative measure at the finer scale. It also provided the fastest image profile capture than profilometry. The sensitivity was the best for atomic force microscopy but decreased when measurements commenced within a large surface irregularity. Optical microscopy and atomic force microscopy showed the best combination for retrieving qualitative and quantitative data on components with a high surface finish, respectively.

EXPERIMENTAL

Polished surfaces are equally important for the medical industry [2,3] as well as the applications to minimize the wear. This relies on suitable methods to observe, monitor and assess the surface quality [1]. This work used optical and stylus methods for qualitative and quantitative assessment, respectively. Precisely positioned surface indents established a viewing window of coarse and fine surface features within the same area with different experimental techniques, Fig.1b.

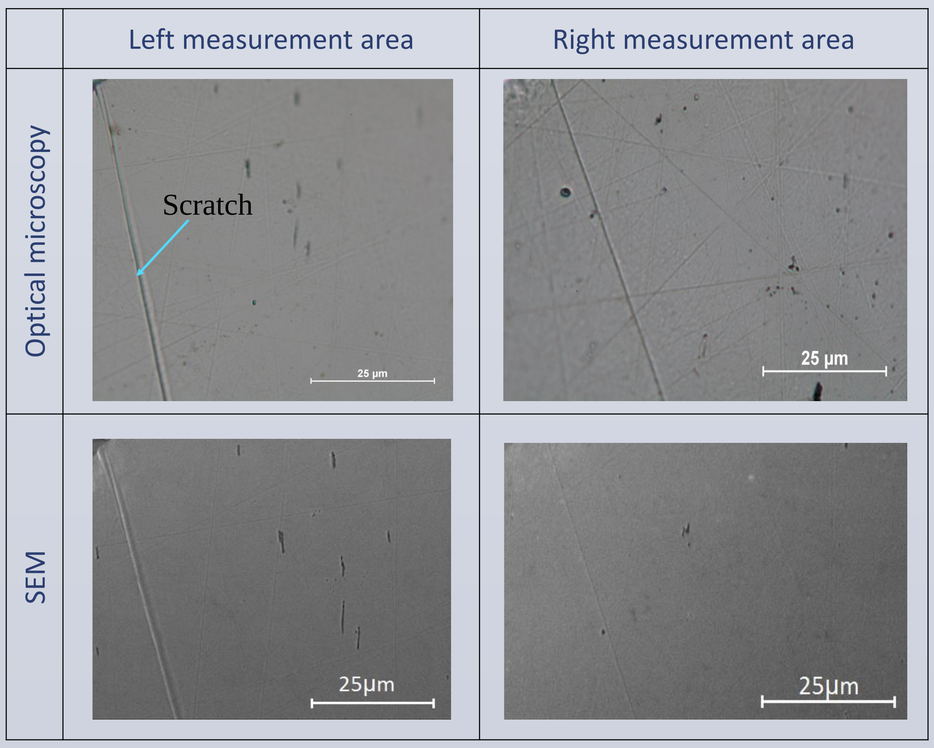
Fig.1. The polished metal sample a) Overall view; b) Measurement area.

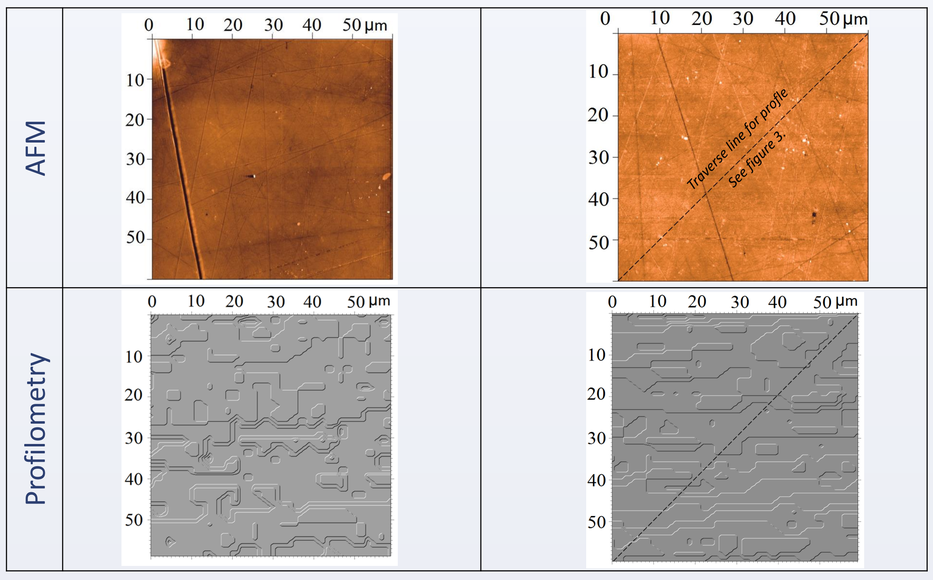
Table.1. Measurement methods, equipment and settings.

Method	Equipment	Measurement settings
Optical microscopy	Nikon LV150 Ecllipse Lens: 100x 0.9 NA	Resolution: 200nm Measurement time: 10min.
Scanning electron microscopy (SEM)	Hitachi S-4800 FE-SEM Detector type: Xflash 5010	Voltage: 15kV, Current: 1nA; Image size: 5120x3840pix.; Measurement time: 30min.
Atomic force microscopy (AFM)	NT&MDT Probe diameter: 10nm	Resolution: 0.1nm; Number of lines: 1024 Measurement time: 30min.
Profilometry	Taylor Hobson Form Talysurf Intra 50 Stylus: 112/2009 (2µm tip)	Number of profiles: 800 Resolution in Z axis: 16nm; Measurement time: 270min

RESULTS AND DISCUSSION

Qualitative assessment methods





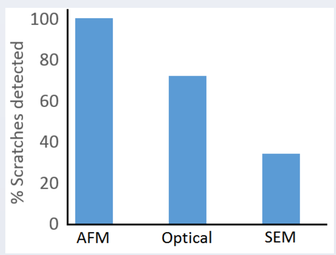


Fig.2. Scratch detection ability.

Qualitative assessment shows that AFM provides the best image quality, followed by optical microscopy, SEM. Profilometry does not show any scratches at a 5000x magnification.

Quantitative assessment methods

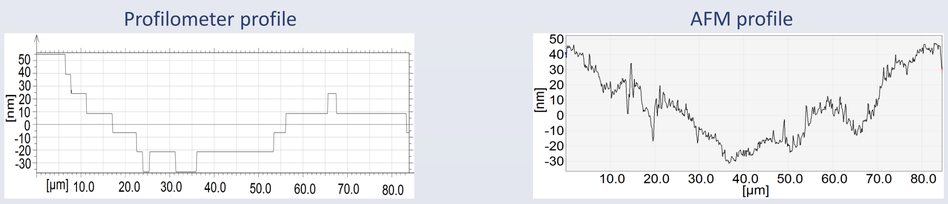


Fig.3. A comparison of profiles from the profilometer and the AFM.

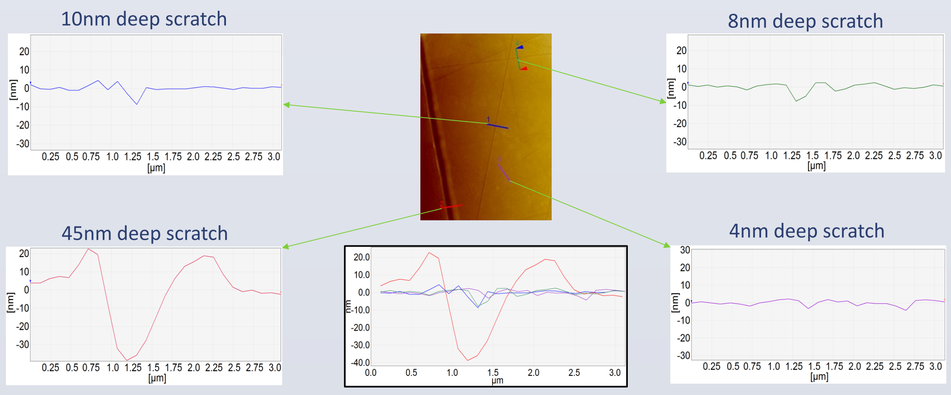


Fig.4. Scratch profiles from AFM data.

Quantitative data shows that AFM provides the best profile which allows the detection of scratches with a depth down to 4nm, while the profilometer only shows 16nm discrete height steps. At high magnification only AFM provides scratch profiles.

CONCLUSIONS

- AFM provides the best qualitative and quantitative information.
- Scratch detection improves in the following order: profilometry, SEM, optical microscopy, AFM.
- Optical microscopy allows the fastest detection of the majority of scratches (~72% of scratches detected by AFM).
- AFM detects scratches from 4nm.

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