Óbudai Egyetem

Tribological properties of In-Situ Si_2N_2O-Si_3N_4 composites

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Aim of the work

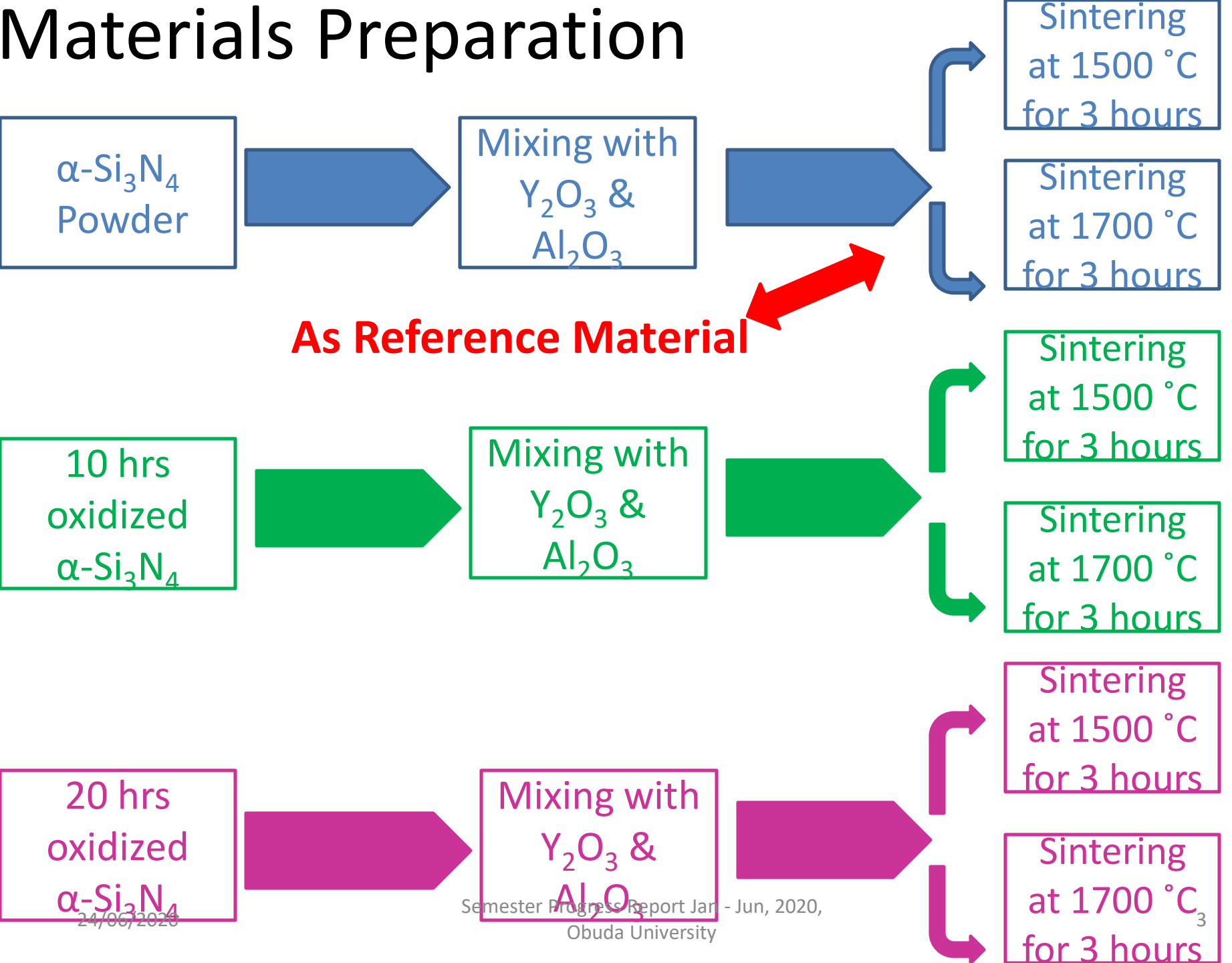
- To study the tribological behaviour of in-situ grown Si_2N_2O in Si_3N_4 composites.

- Following parameters were studied:

➢ Wear Mechanism

➢ Coefficient of friction

Materials Preparation



Samples Details

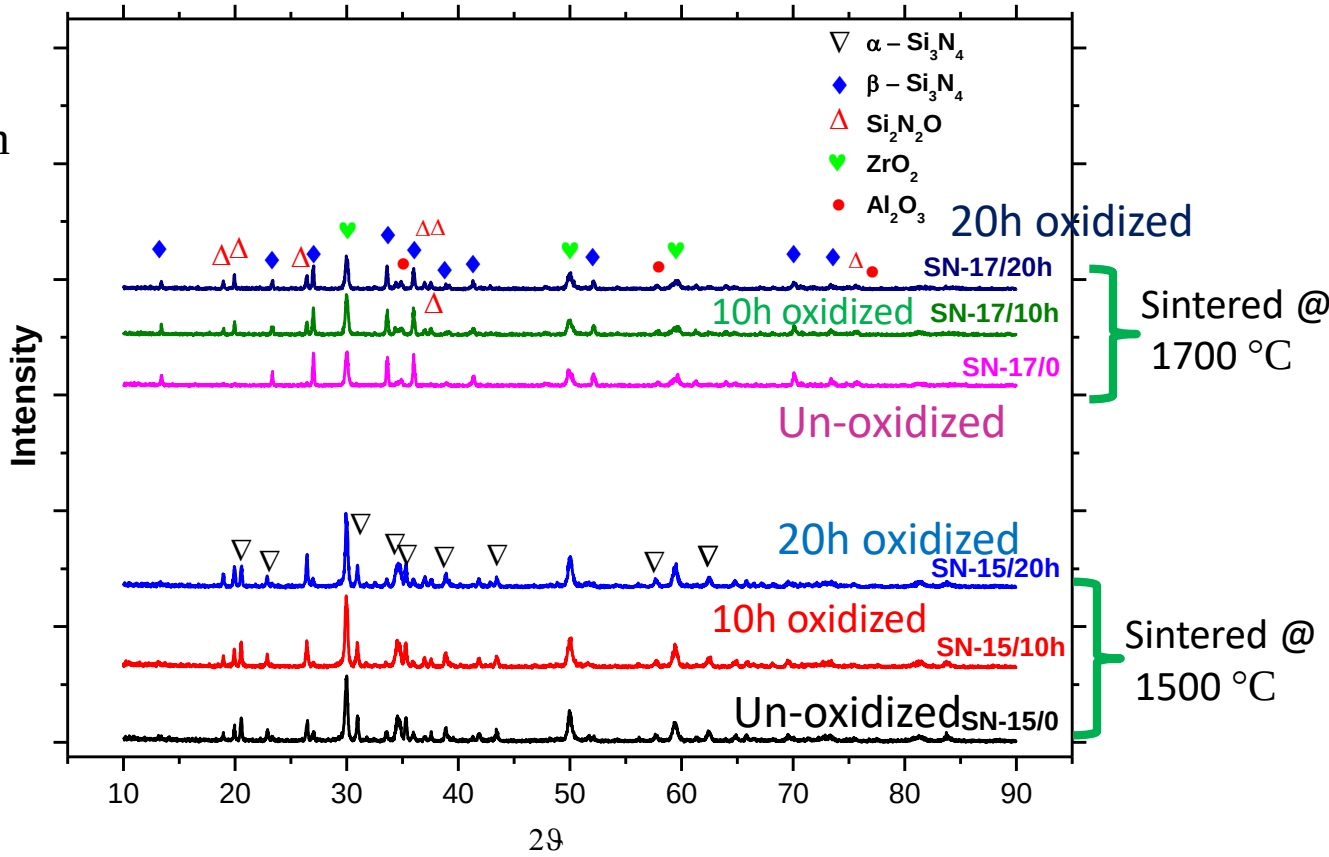
		Oxidation Time (h)	α-Si_3N_4 (wt. %)	Y_2O_3 (wt. %)	Al_2O_3 (wt. %)
Un-oxidized	SN-15/0	0	90	6	4
10h oxidized	SN-15/10h	10	90	6	4
20h oxidized	SN-15/20h	20	90	6	4
Un-oxidized	SN-17/0	0	90	6	4
10h oxidized	SN-17/10h	10	90	6	4
20h oxidized	SN-17/20h	20	90	6	4

Complete α to β transformation happened in case of sample sintered at 1700 °C.

XRD Analysis

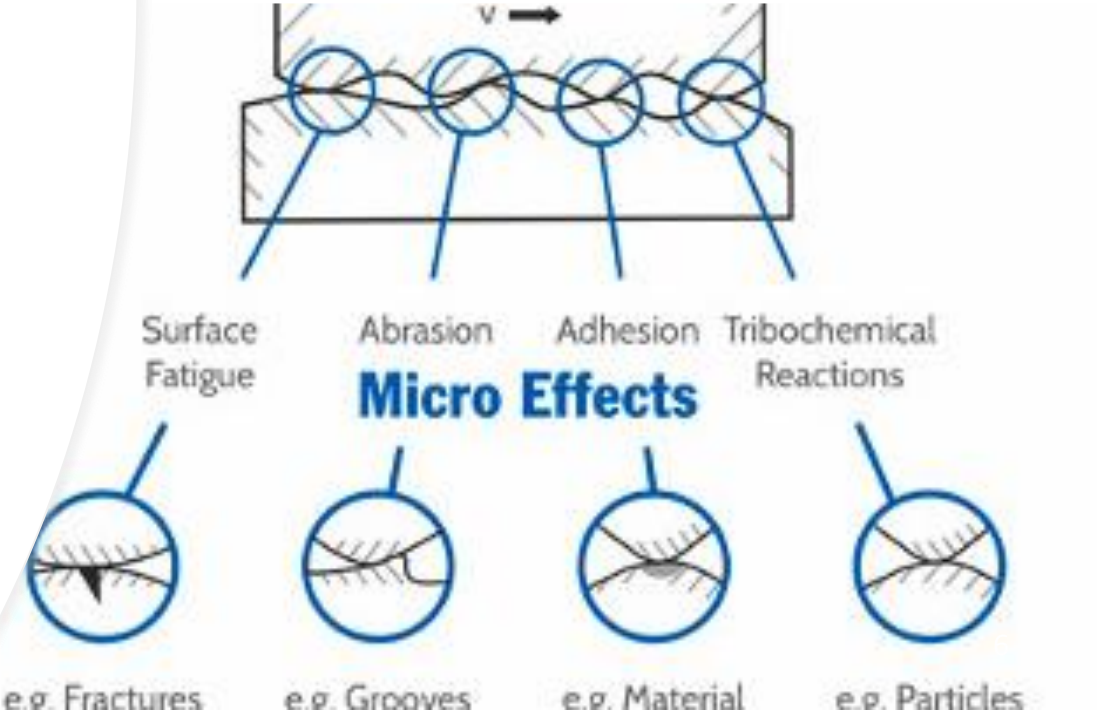
Phase Si_2N_2O appeared in samples which processed from the oxidized powders.

The amount of Si_2N_2O increasing with the oxidation time or amount oxides in starting powders.

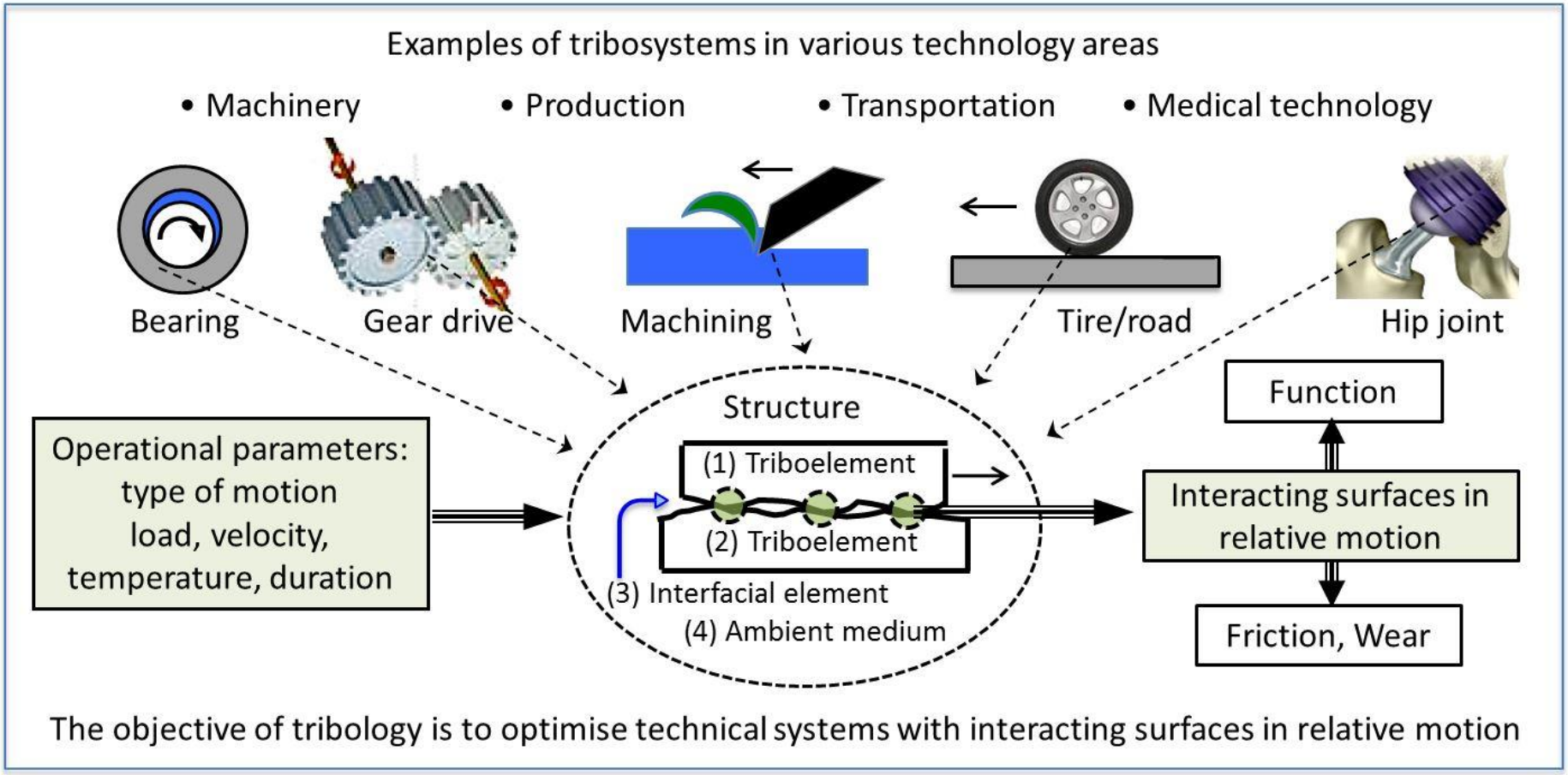


What is Tribology

- Tribology = Greek word “Tribos”
  Tribos = “Rubbing and Sliding”
- Tribology is a scientific study which deals with friction, lubrication and wear of contacting bodies.
- Tribological knowledge helps to improve service life, safety and reliability of interacting machine components and yields in economic benefits.

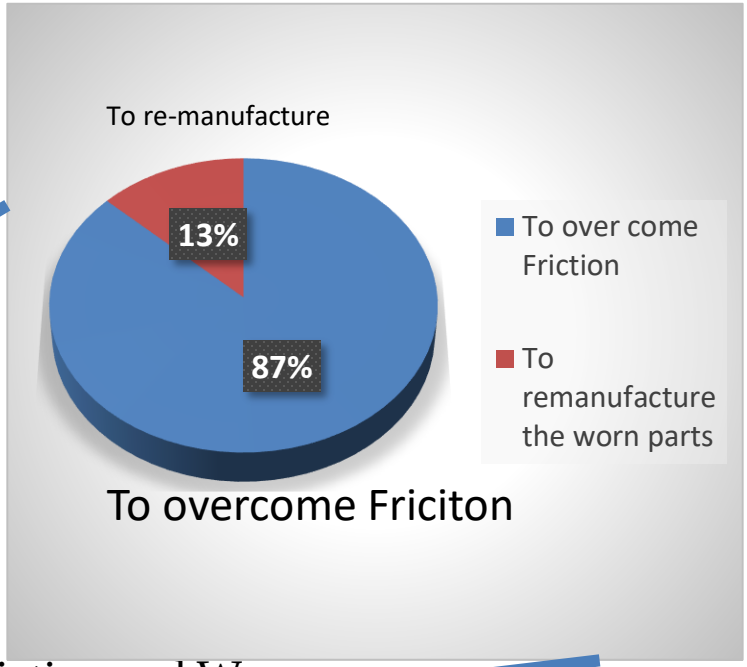


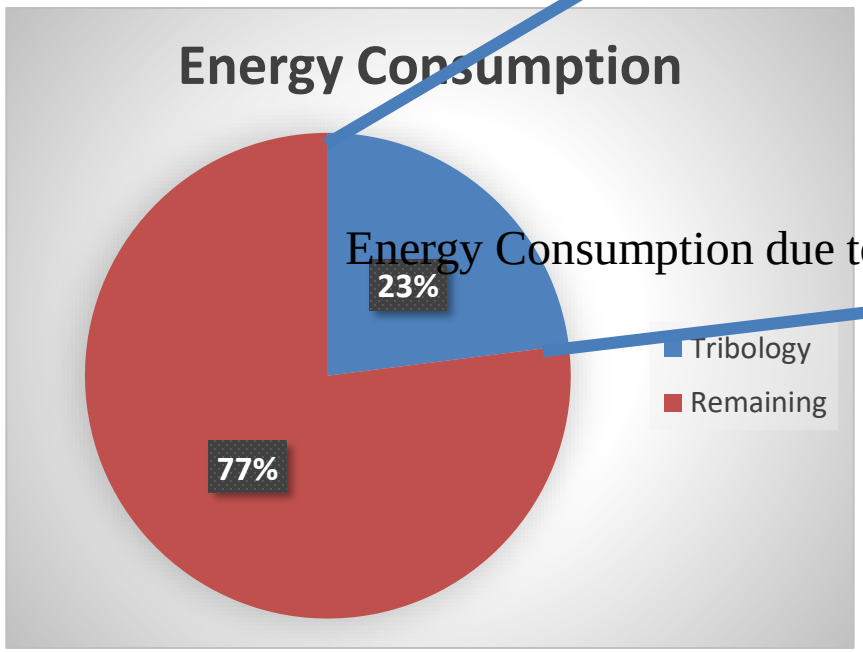
What is Tribology and its importance?



Source: H. Czichos and M. Woydt: Introduction to Tribology and Tribological Parameters. ASM handbook, Vol. 18, Friction, Lubrication and Wear Technology, 2017

Impact of Tribological Issues on Global Economy





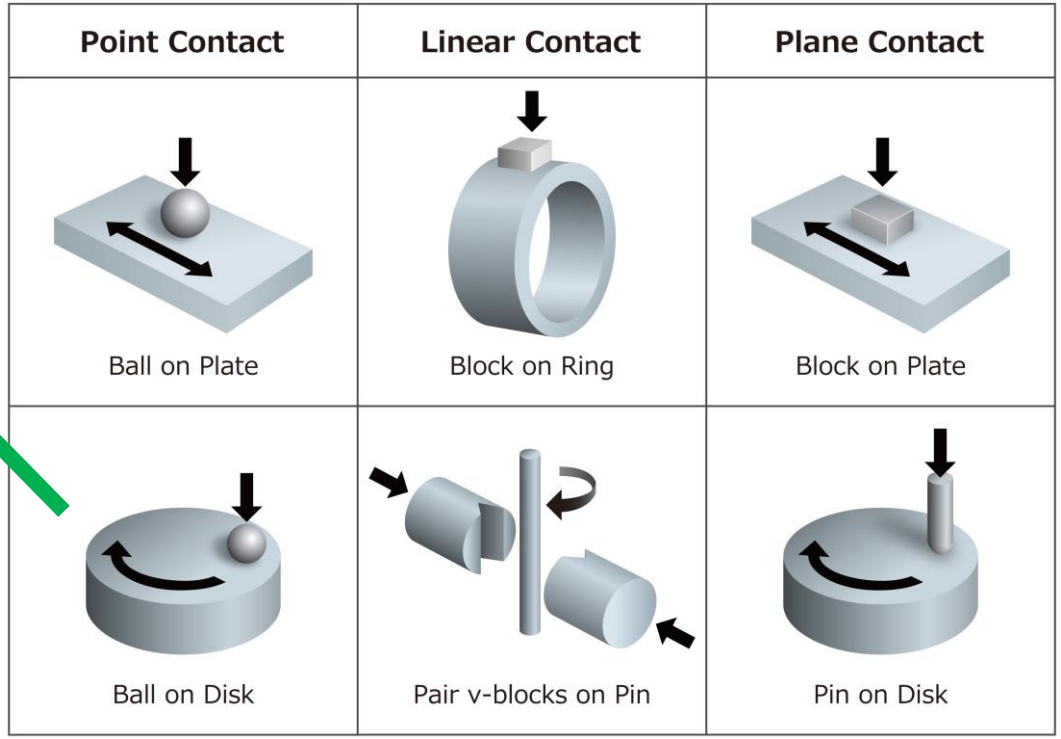
Energy Consumption due to Friction and Wear

Source: K. Holmberg and A. Erdemir, "Influence of tribology on global energy consumption, costs and emissions," *Friction*, vol. 5, no. 3, pp. 263–284, Sep. 2017.

Tribological Testing of our samples

Ball-on-disk technique
Counter part = Si_3N_4 ball (D=5 mm)
Condition = Dry sliding condition
Temperature = Room temperature (25 C)
Humidity = 51%
Normal applied load = 5 N
Sliding speed = 0.05 m/s
Sliding distance = 1000 m.

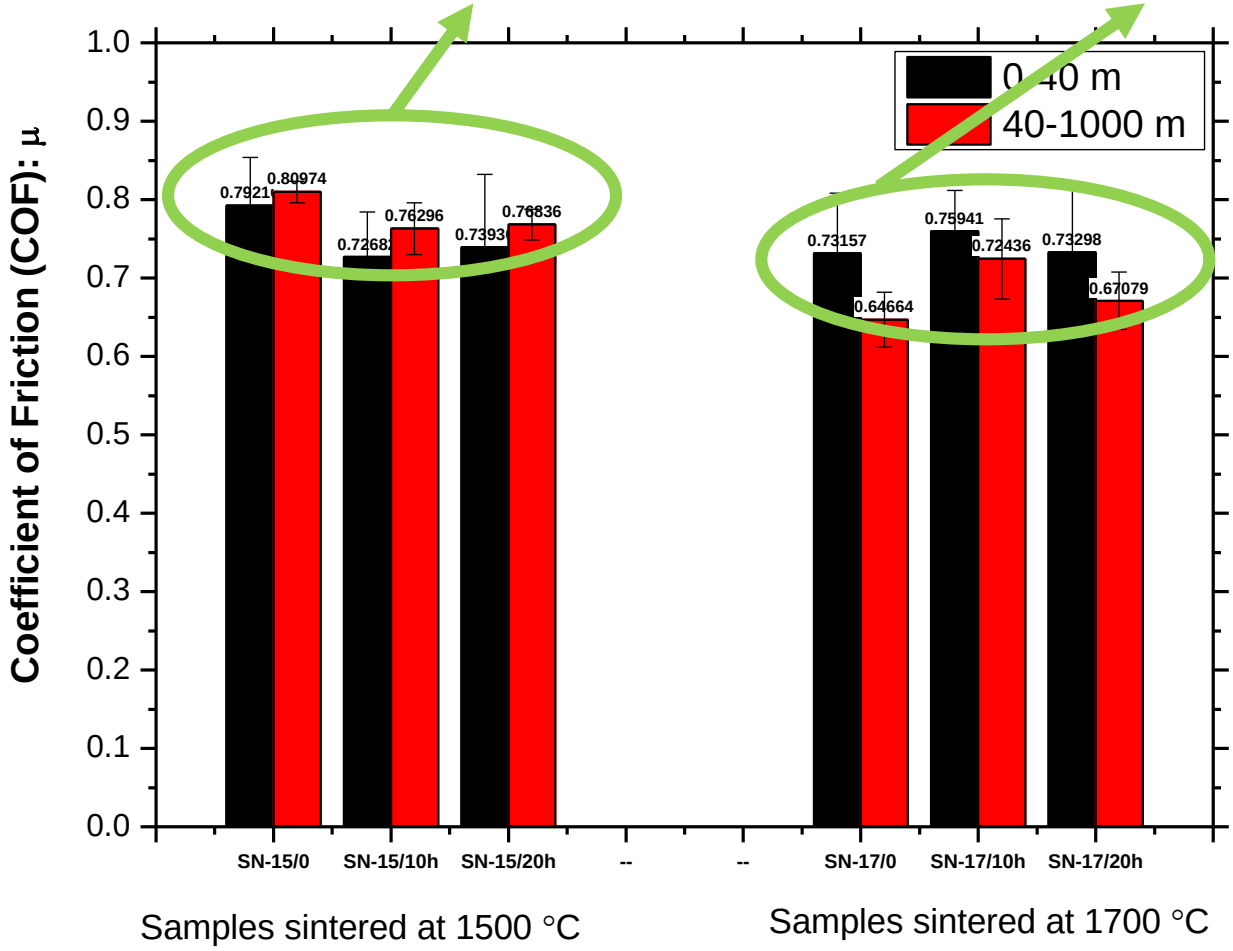
Different types of testing techniques



Source: Source: https://www.face-kyowa.co.jp/english/en_science/en_what_friction.html

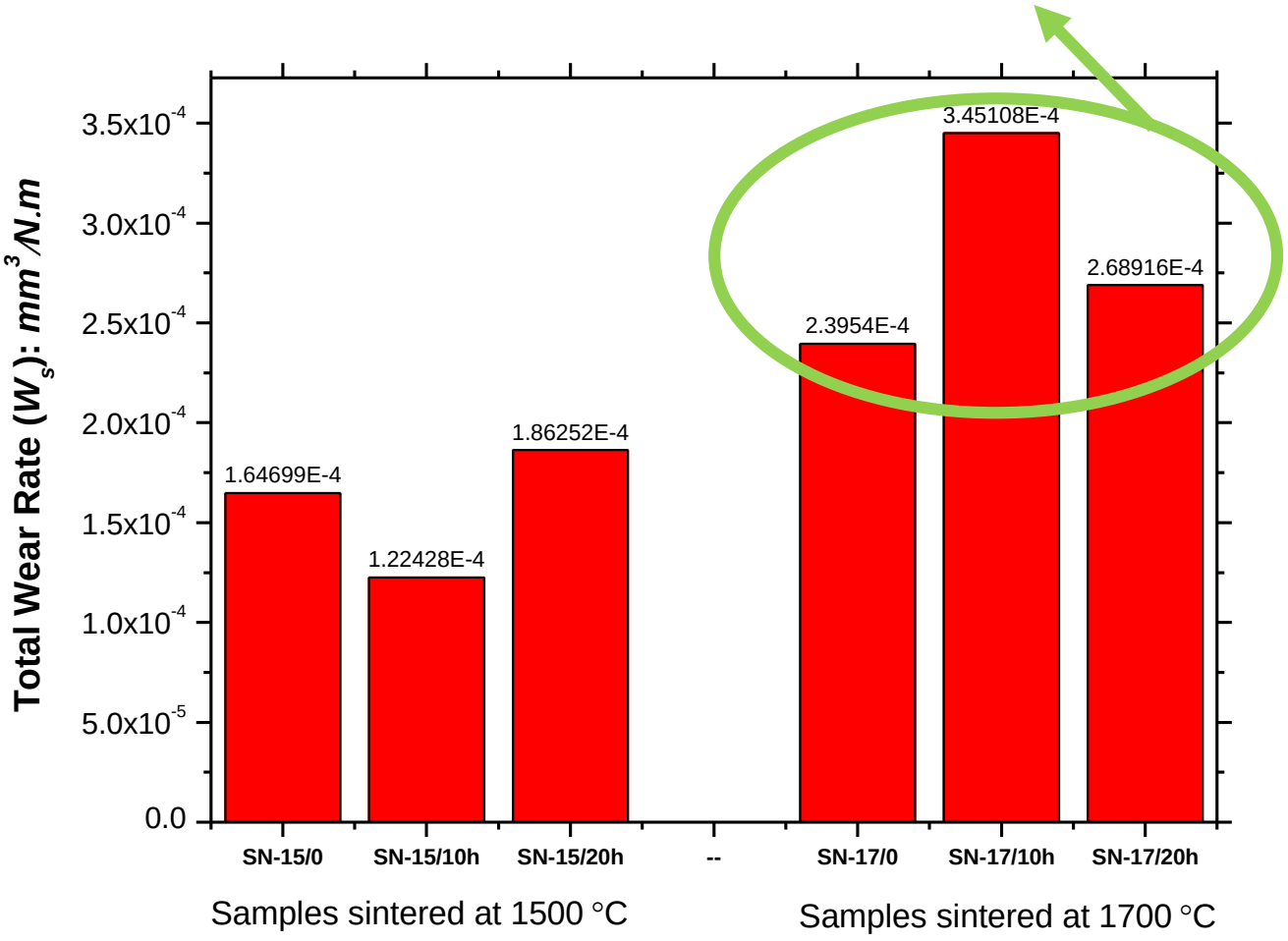
Coefficient of Friction

Overall, COF of samples sintered at 1500 C was higher than that of 1700 C



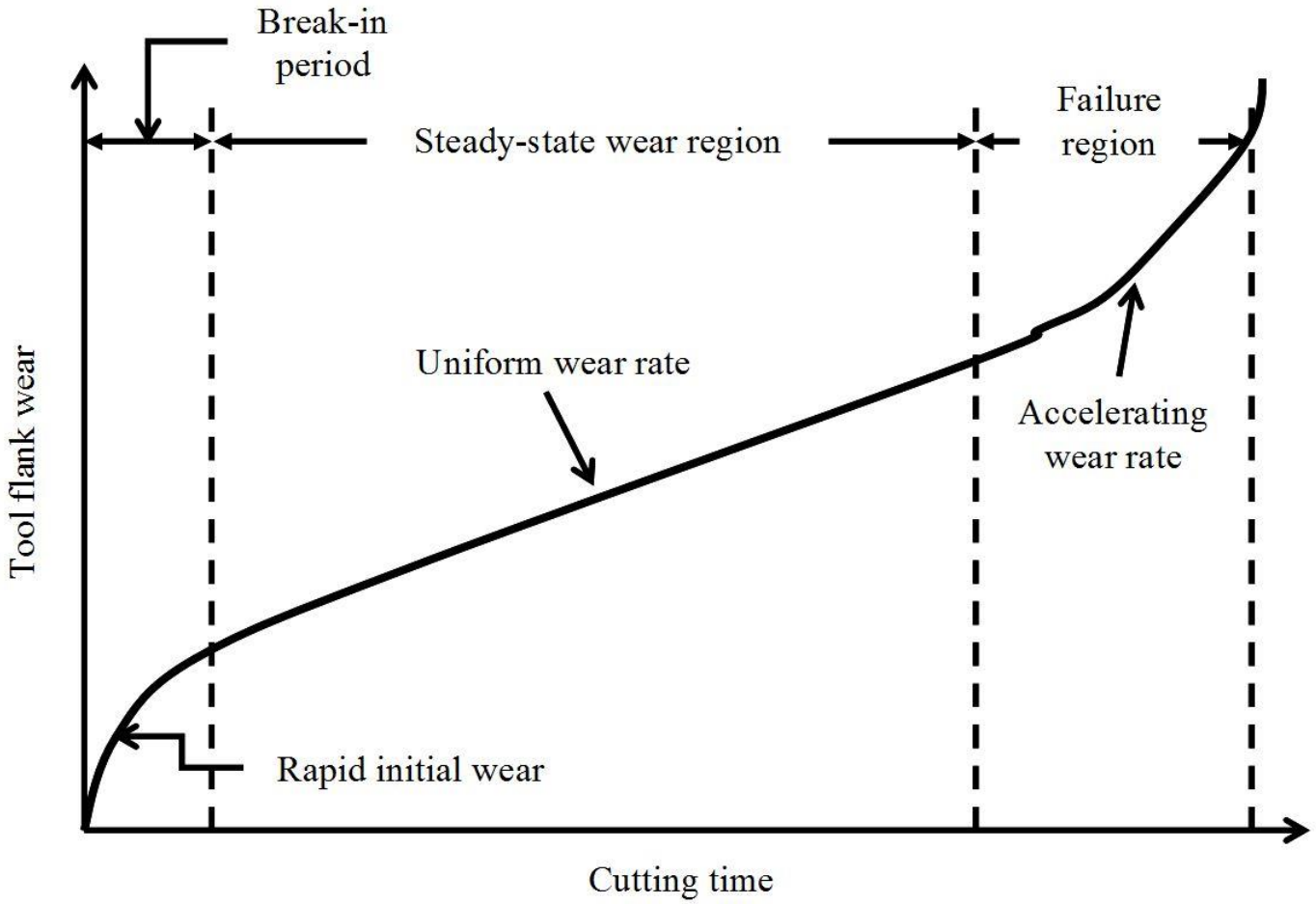
Wear Rate

Wear Rate of samples sintered at 1700 °C was higher than that of 1500 °C



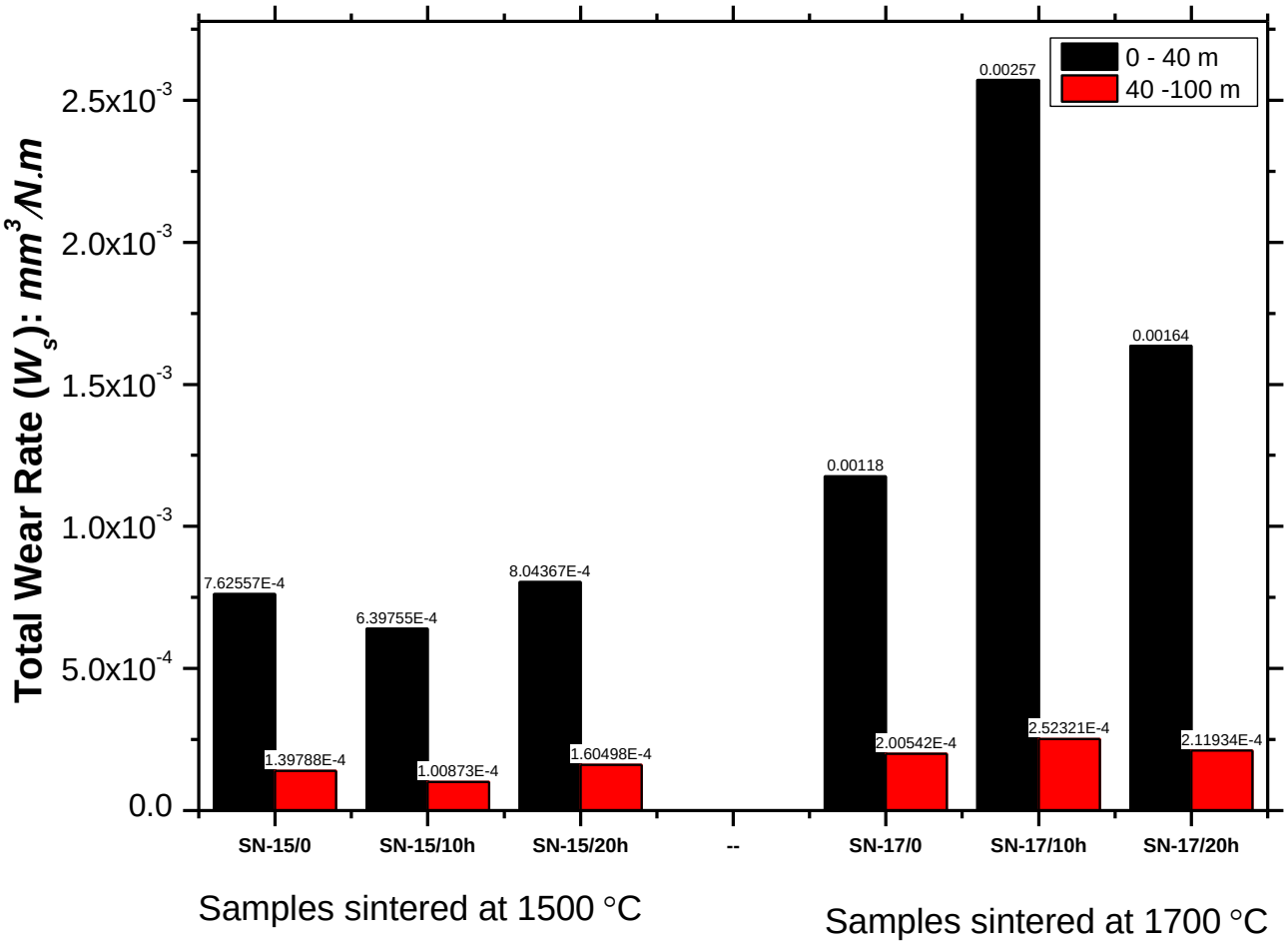
Low wear rate can be attributes to the present amount alpha phase, Alpha phase is harder and robust than beta phase.

Stages of Wear Rate



Source: Machinability of Titanium Alloys in Drilling
By Safian Sharif, Erween Abd Rahim and Hiroyuki Sasahara
Submitted: May 17th 2011Reviewed: October 12th 2011Published: March 16th 2012
DOI: 10.5772/35948

Wear rate in Different Stages

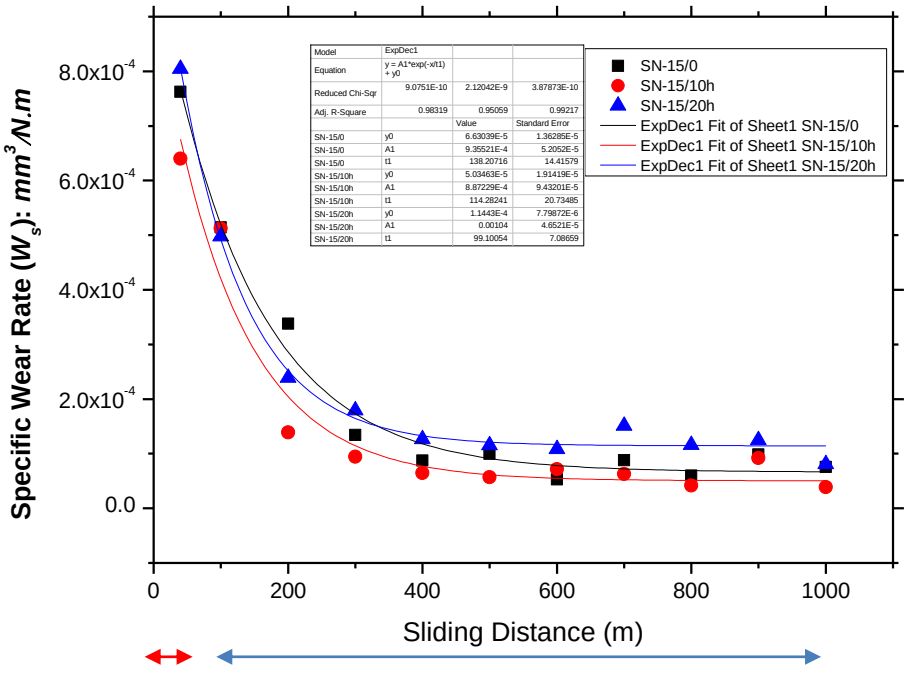


For our samples, the first 40 m of sliding is a *run-in stage*

In first 0-40 m (*run-in stage*), the wear rate was almost time higher than the overall wear rate.

Wear rate at every 100 m

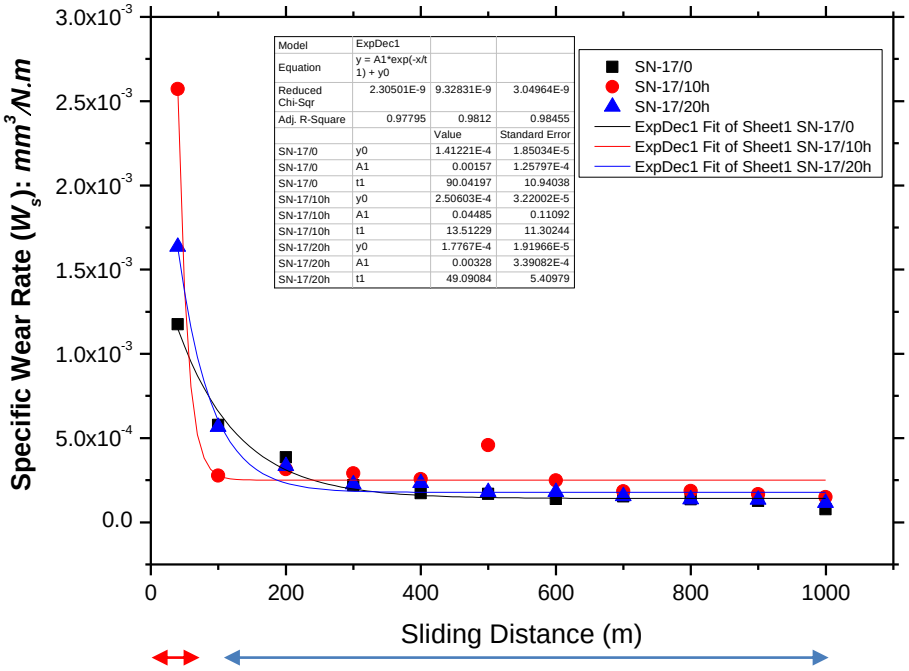
Sintered at 1500 °C



Run-in
0-40 m

Steady State
40-1000 m

Sintered at 1700 °C

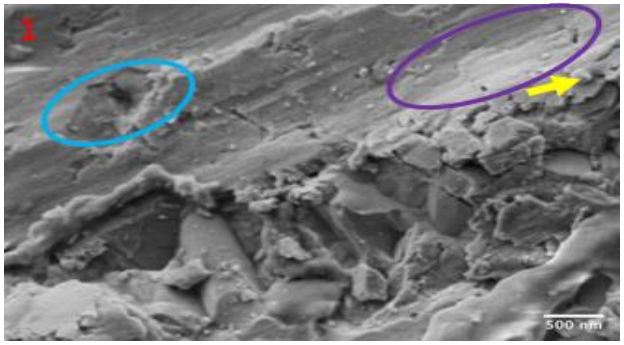


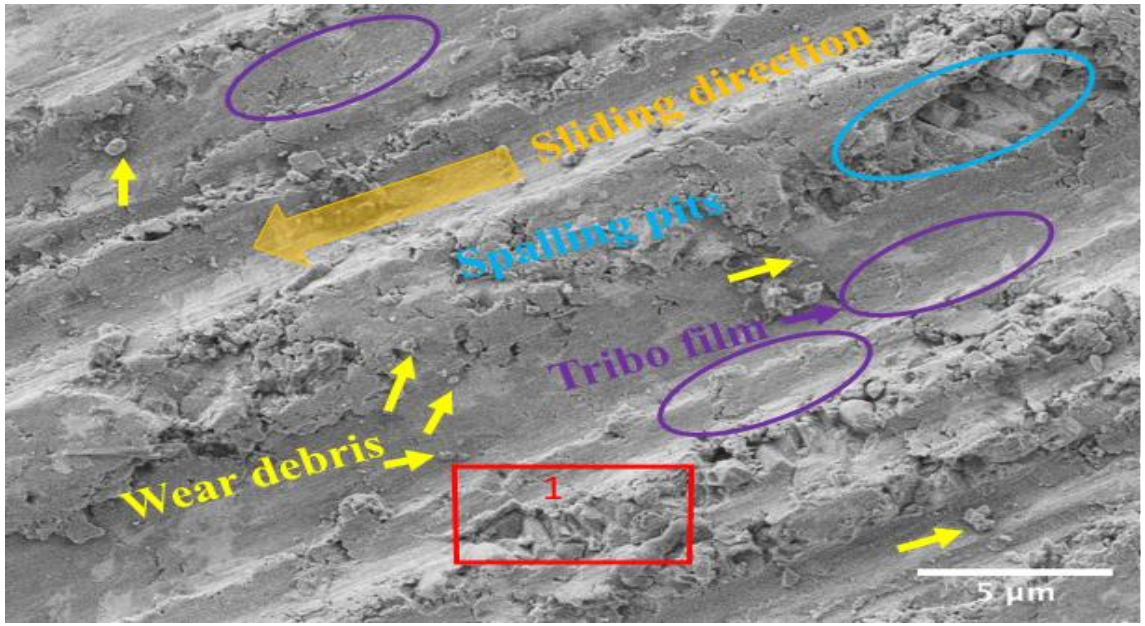
Run-in
0-40 m

Steady State
40-1000 m

Wear Mechanism

SEM Image of wear track





Conclusion

- Oxidizing the starting powders of Si_3N_4 is successful in order to grow *in-situ* Si_2N_2O in sintered Si_3N_4.

- The wear rate in *run-in stage* is much higher than that of *steady-state* stage. 1000 m sliding distance is still a steady state, no catastrophic failure was observed.

- The COF is higher for the composites sintered at 1500 °C and lower wear rates due to the presence of higher amount of α - Si_3N_4 in the composite.

Publication 2017 - 2020

1. **A. Qadir**, Z. Fogarassy, Z. E. Horváth, K. Balazsi, and C. Balazsi, "Effect of the oxidization of Si3N4 powder on the microstructural and mechanical properties of hot isostatic pressed silicon nitride," Ceramics International, vol. 44, no. 12, pp. 14601–14609, Aug. 2018. (Impact Factor 2.986). https://doi.org/10.1016/j.ceramint.2018.05.081

2. **Awais, Q.,** Balazsi, K., Balazsi, C., Ivor, M. and Dusza, J., 2020. Properties of MWCNTs added Si3N4 composites processed from oxidized silicon nitride powders. *Processing and Application of Ceramics*, *14*(1), pp.25-31.(Impact Factor: 1.085). https://doi.org/10.2298/PAC2001025Q

3. **Qadir, A.;** Pinke, P.; Dusza, J. Silicon Nitride-Based Composites with the Addition of CNTs—A Review of Recent Progress, Challenges, and Future Prospects. Materials 2020, 13, 2799. (Impact Factor 2.972) https://doi.org/10.3390/ma13122799

4. **Awais, Qadir** ; Jan, Dusza ; Pinke, Péter, Tribological Behavior of Silicon Nitride and Carbon Based Filler Composites – a Review, In: Horváth, Richárd; Beke, Éva; Stadler, Róbert Gábor (eds.) Mérnöki Szimpózium a Bánkin előadásai : Proceedings of the Engineering Symposium at Bánki (ESB 2019), Budapest, Hungary : Obuda University, (2019) pp. 7-16. , 10 p

5. Tribological properties of in-situ grown Si_2N_2O-Si_3N_4 composites, (In Progress)

Thank You for your attention!

Köszönöm a figyelmet!