CHEMISTRY & CHEMICAL TECHNOLOGY
CONFERENCE 2021 VILNIUS

16th International Conference of Lithuanian Chemical Society
"CHEMISTRY AND CHEMICAL TECHNOLOGY 2021"
September 24, 2021, Vilnius, Lithuania

FIZINIŲ IR TECHNOLOGIJOS MOKSLŲ CENTRAS

HARDNESS AND WEAR PROPERTIES OF ALD HfO_2 LAYERS ON AZ31 ALLOY

A. Griguc̆evičienė*, L. Staišiūnas, L. Valantiejūtė, K. Leinartas, E. Juzeliūnas

Centre for Physical Sciences and Technology, Saulėtekio av. 3, LT-10257 Vilnius

*e-mail: asta.griguceviciene@ftmc.lt

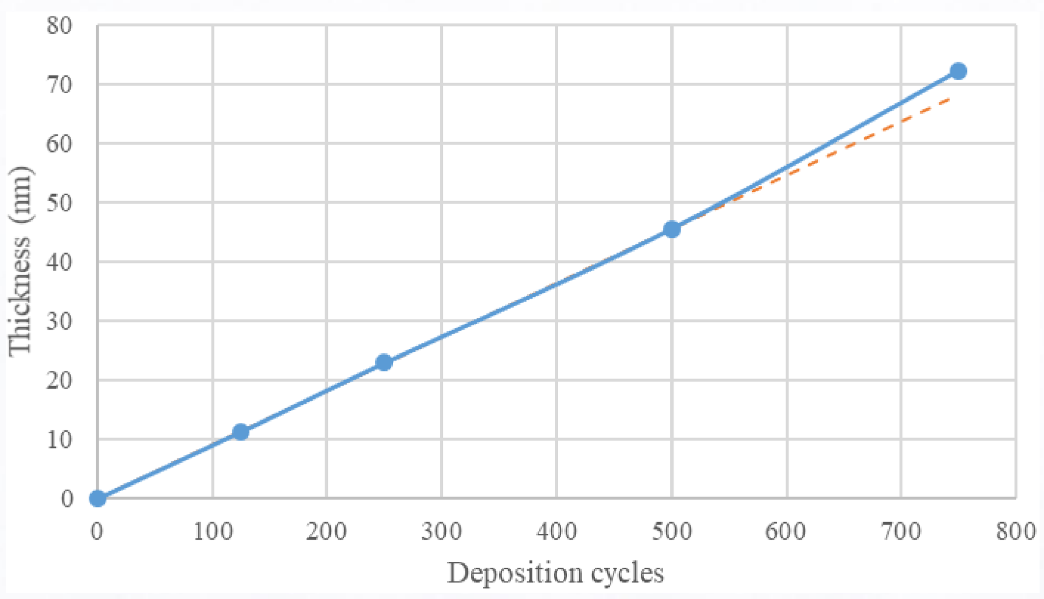
INTRODUCTION

Exceptional mechanical properties of Mg and its alloys (lightness, great strength-to-weight ratio) allow them to be used in a variety of applications, including automobile and aviation industries, consumer electronics, biomaterials. However, the poor resistance of magnesium to corrosion and wear significantly limits and complicates its use. One of the ways to improve both corrosion performance and wear resistance of magnesium alloys is to coat their surface with chemically inert, mechanically hard oxides. Hafnium oxide (HfO_2) is considered as a promising candidate for this purpose [1, 2]. Atomic Layer Deposition (ALD) is the most suitable modern method to deposit thin oxide layers of a predictable thickness.

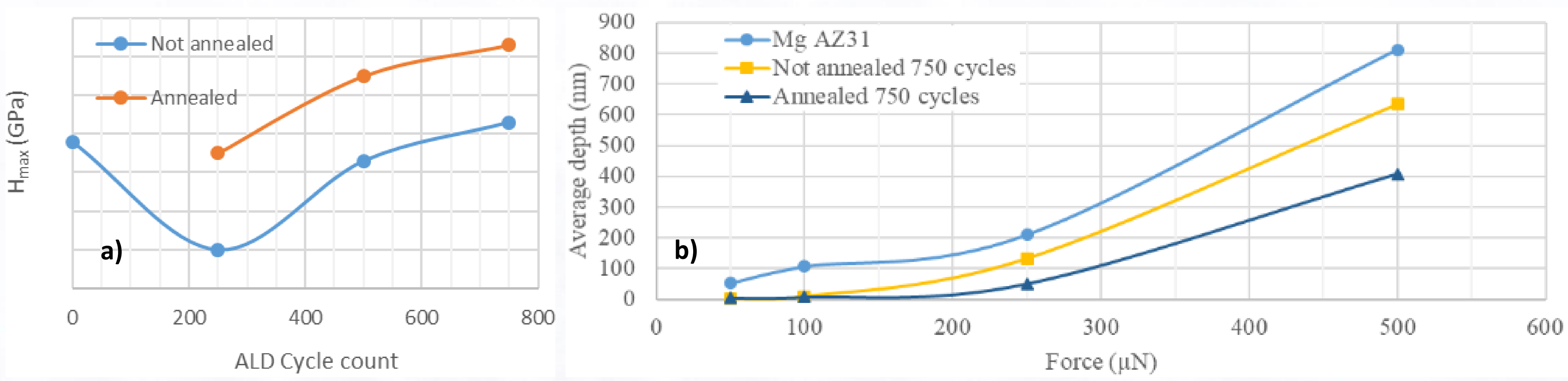
EXPERIMENTAL

In this study, magnesium alloy AZ31 (Mg-3Al-Zn) was coated with HfO_2 layers of different thicknesses. The growth rate of HfO_2 (nm/cycle) was evaluated. Samples were tested as deposited and after annealing in nitrogen atmosphere at 350 ºC for 5 hours. All samples were tested for hardness and wear with nanoindenter.

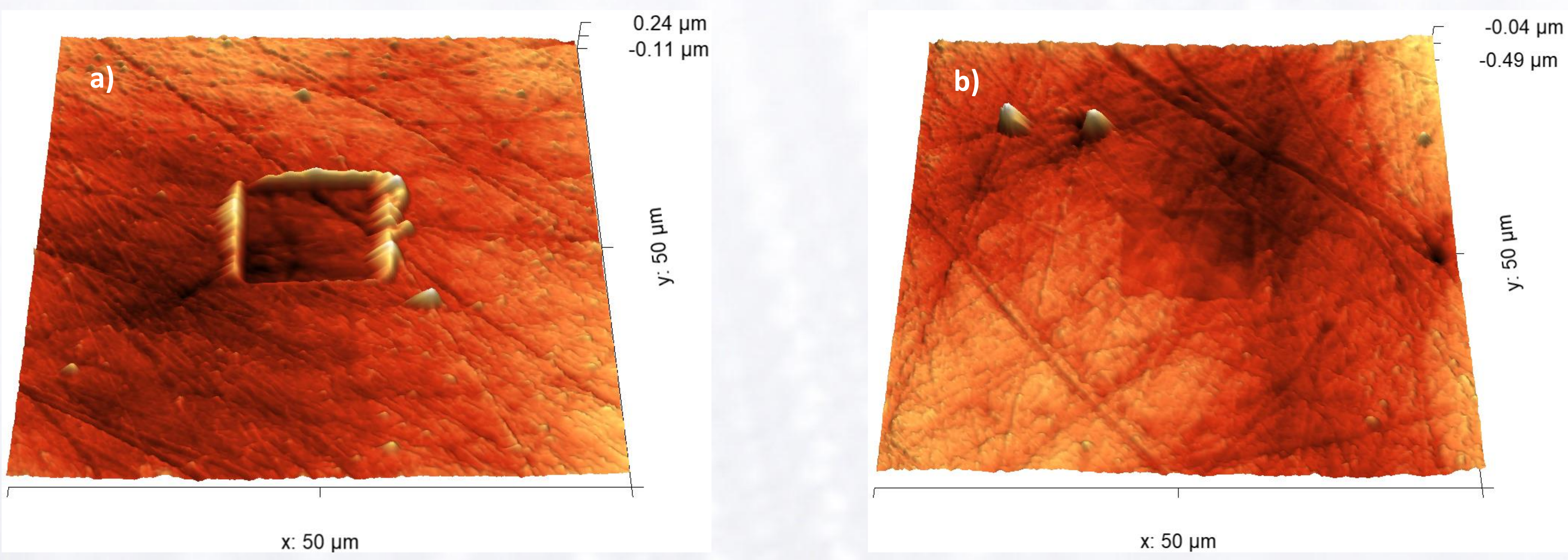
RESULTS



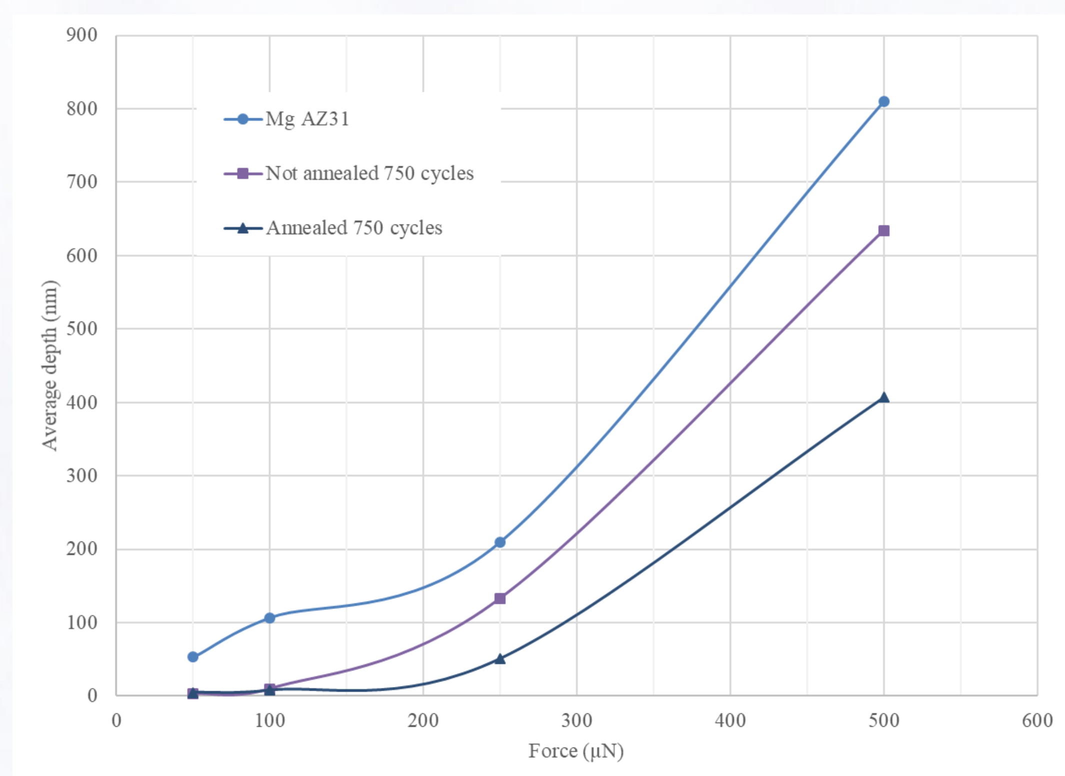
HfO_2 layer thickness dependency on deposition cycles with trendline equation



Hardness of AZ31 alloy coated with HfO_2 coatings of various thickness (a) and average wear depth of uncoated and 750-cycle ALD coated AZ31 samples (b).



SPM image of a wear trace of uncoated AZ31 alloy (a) and coated with 750 ALD cycles of HfO_2.



Graphs of average wear depth dependence on wear force for not annealed and annealed samples of 750 cycles and Mg alloy

CONCLUSIONS

- The ALD growth of HfO_2 at 200 ºC reactor temperature was determined to be linear in the region from 0 to 45 nm and the growth rate was calculated to be ~0.091 nm/cycle.
- The surface hardness of AZ31 with natural oxide/hydroxide layer was better than that of samples with HfO_2 coatings of 250 and 500 ALD cycles. HfO_2 coating of 750 ALD cycles was already harder than natural oxide: ~4.3 GPa, compared to ~4GPa for uncoated AZ31. The annealing improved hardness of the samples up to ~6.3 GPa for 750 cycle ALD coating.
- Wear tests showed that HfO_2 coatings provided additional wear resistance for AZ31 samples compared to natural oxide/hydroxide layer. At 100 µN load, the annealed and not annealed samples with 750 cycle ALD coating, showed significant wear resistance with wear depth less than 15 nm. At higher loads some wear reduction effect was found which increased with the coating thickness. Hardness and wear resistance of all samples increased with annealing.

References

1. M. Li, Z. Jin, W. Zhang, Y. Bai, Y. Cao, W. Li, D. Wu, A. Li. Sci. Rep., 9:10438 (2019); doi.org/10.1038/s41598-019-47049-z.
2. L. Staišiūnas, K. Leinartas, E. Juzeliūnas, D. Bučinskienė, A. Grigucevičienė, P. Kalinauskas, A. Selskis, S.Stanionytė. Surf Coat Technol., 397 (2020) 126046; doi.org/10.1016/j.surfcoat.2020.126046.