Aalto University

Surface engineering of dental instruments

Impact case study
Department of CMAT 2018

Aalto RAI 2018 Case Study

Field: 3b

Unit of Assessment (UoA): CMAT Department

Surface engineering of dental instruments

1. Summary of the societal impact

In order to maintain a leading position in the world market, products should exhibit better functionality and durability. Such enhanced performance can be achieved by surface engineering, applying thin film coatings and/or functional materials. This Case study presents development of dental instruments of LM-Instruments Oy (https://www.lm-dental.com/) with improved performance and increased lifetime. By applying a hybrid coating with high corrosion resistance, the instruments can be made of high strength steel materials with clearly superior mechanical properties. The hybrid coating consisted of a physical vapor deposition coating of chromium nitride and of atomic layer deposition (ALD) nanolaminate of TiO_2/Al_2O_3. These new instruments reduce the need for re-sharpening and increase their lifetime. Furthermore, a new omniphobic non-stick coating on textured metal was developed on dental restorative instruments. This research helped the company in its R&D indirectly and demonstrated novel means to develop next generation products. These studies were carried out in a Tekes funded SHOK program with collaboration of 36 different Finnish companies and 7 research partners.

2. Underpinning research activity related to Aalto activities

Surface engineering and thin films development are important for functional materials. In principle, wear, friction and surface wettability are properties, which determine the performance of tools and components in engineering. In Finnish industry there has been a long tradition to develop surface functionality of components and this has reflected to the research activities of the CMAT (and the preceeding MSE) department. In recent years, particularly the advanced functional surfaces have been boosted by the new innovations, development of ALD and carbon thin films. In the Tekes funded SHOK program HYBRIDS, these technologies were applied to the dental instruments by the Prof. Koskinen's research group. This SHOK program was finalized on 2017. Its volume was 9 M€, and the research was carried out by a consortium of 7 research parties (including Aalto University) and 36 company partners.[1] Research activities were coordinated in separate tasks, jointly with several partners. The Task partners in this functional coating development were Fiskars Finland Oy, LM-Instruments Oy, Oras Oy , Picosun Oy, Picodeon Oy, Aalto University (CMAT), Tampere University of Technology and VTT.

3. References to research activities

Journal articles to be part of doctoral thesis 2018 of Jarmo Leppäniemi.

I) J. Leppäniemi, J. Lyytinen, O. Elomaa, K. Suomalainen, J. Koskinen.
The influence of PVD coatings on the wear performance of steel dental curettes.
Key Engineering Materials, 2016, **674,** 289-295. DOI: 10.4028/www.scientific.net/KEM.674.289

II) J. Leppäniemi, P. Sippola, M. Broas, J. Aromaa, H. Lipsanen, J. Koskinen.
Corrosion protection of steel with multilayer coatings: Improving the sealing properties of physical vapor deposition CrN coatings with Al_2O_3/TiO_2 atomic layer deposition nanolaminates. *Thin Solid Films*, 2017, **627**, 59-68. DOI: 10.1016/j.tsf.2017.02.050

III) J. Leppäniemi, S. Hoshian, K. Suomalainen, T. Luoto, V. Jokinen, J. Koskinen.
Non-stick properties for dental restorative instruments by thin film coatings.
European Journal of Oral Sciences, 2017, **125.6**, 495-503. DOI: 10.1111/eos.12372

IV) J. Leppäniemi, P. Sippola, A. Peltonen, J. Aromaa, H. Lipsanen, J. Koskinen.
Effect of surface wear on corrosion protection of steel by CrN coatings sealed with Atomic Layer Deposition. *ACS Omega*, 2018, **3**, 1791–1800. DOI: 10.1021/acsomega.7b01382

[1] http://hightech.dimecc.com/results/final-report-hybrids-hybrid-materials

DIMECC Final Report: Hybrids “Hybrid Materials”, Dimecc Publications series No. 18 (5/2017) ISBN 978-952-238-196-5 (pdf), ISSN 2342-2696 (online) http://hightech.dimecc.com/results/final-report-hybrids-hybrid-materials

4. Societal Impact, activities and roadmap for the case

The impact of the project was finding competitive and sustainable new products and to allow development of competitiveness of the Finnish industry in the long term. The main outcome were the new dental instrument products of LM Instruments Oy. Our research provided tools and surface solutions to realize the company’s own product development in its next generation products. Our research was carried out, discussed and co-created with the other project partners in order to focus the research to the most feasible solutions. The co-operation and co-creation with the partners in this research task was essential. The partners organized about four annual documented meetings. FIMECC (later DIMECC) organized annual impact days for the consortium, as well as publicly for the research and industrial community. Thus, the results of the project were directly beneficial to the company’s R&D as documented in Tekniikka&Talous article.[2] In addition to these specific company targeted impacts, our scientific research enabled more generic impact to other industrial companies and research units nationwide, even globally.

5. Sources to support the impact case

New products of LM Instruments as notified in Tekniikka&Talous (footnote 2)

6. Future goals

This Case study demonstrated that Aalto University can combine the high level scientific research with company R&D interests. This co-operation will be essential to guarantee the societal impact of CMAT in the field of functional materials. It will be possible that new funding instruments motivating the universities and Finnish companies to return to close collaboration will be provided, even after the dramatic reduction of Tekes funding during the past three years.

[2] Kari Peltonen, Tekniikka&talous 7.11.2016,”Tarttumaton pinta tehostaa työkalua”, https://www.tekniikkatalous.fi/ttpaiva/tarttumaton-pinta-tehostaa-tyokalua-6597295

Appendix

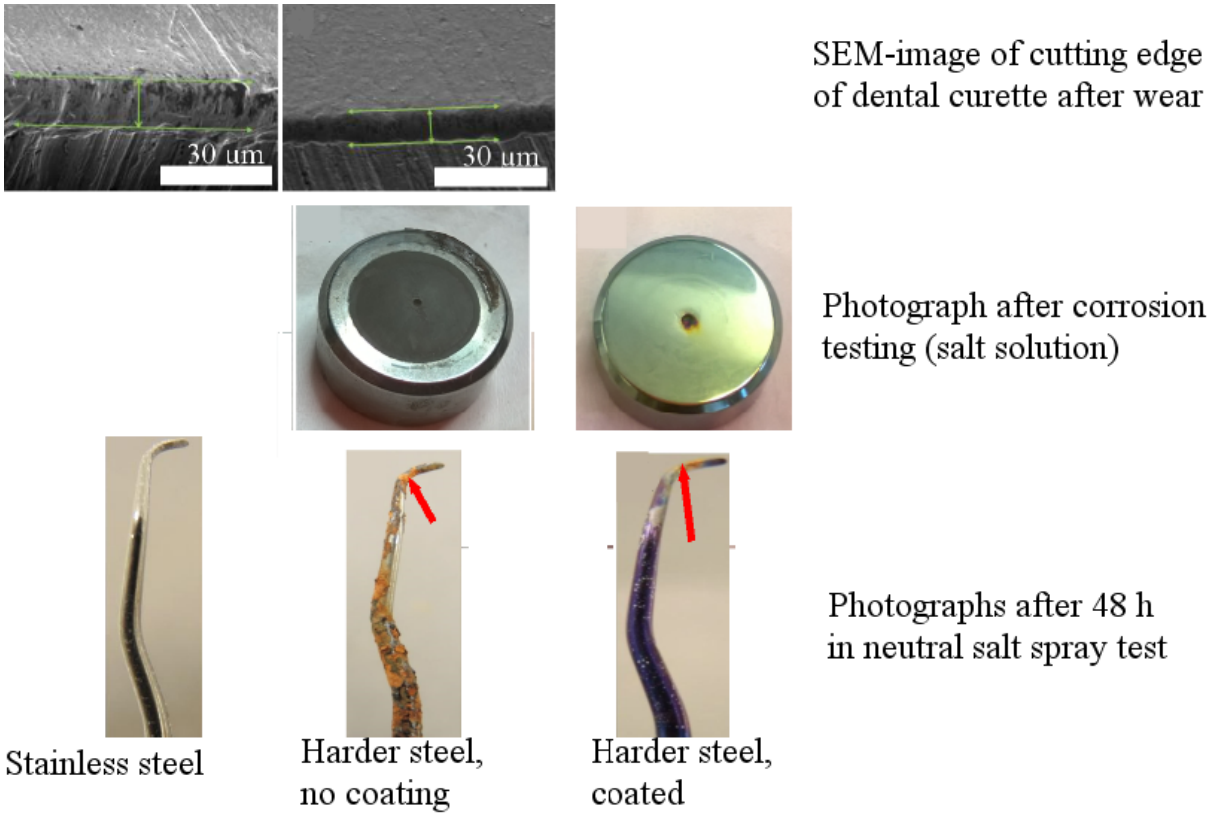

Figure: Left: Previously used stainless steel. Abrasive blunting at cutting edge warrant resharpening. Middle: Using harder steel material reduces wear (measured as increase in width of cutting edge) by 67%, but this steel material is very prone to corrosion. Right: hybrid PVD/ALD coating protects harder steel material from corrosion. Images taken from [I] (upper row) and [II] (middle and lower row).

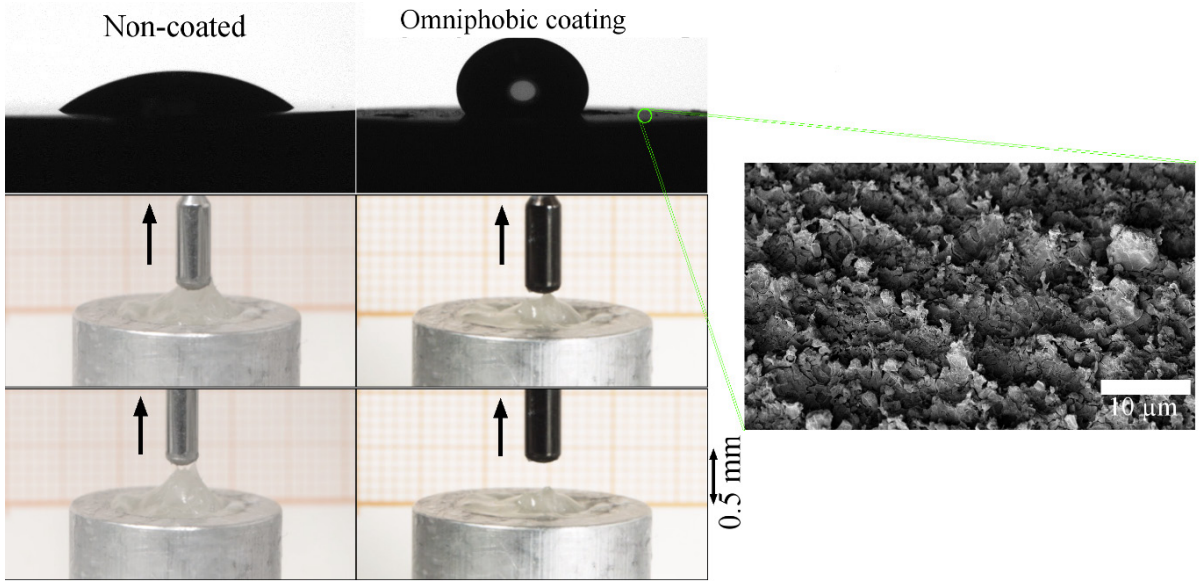

Figure 2: Left: non-coated restorative instrument. Middle: in-house fabricated omniphobic coated instrument. Right: SEM-image of textured surface, before coating deposition. Image taken from [III].