Atmospheric Plasma Jet SiOx-Thin-Film Deposition on Enamel

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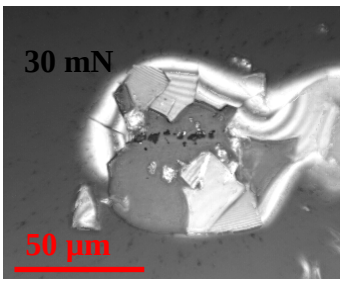
Physical plasmas have found manifold applications in industry and in medicine in recent years [1]. In medicine plasmas were successfully applied for instance for surface cleaning, sterilisation and disinfection [2-3]. Modifications of tooth surfaces are generally interesting for improvements in restorative dentistry. State of the art inhibition of pit and fissure caries is practiced by sealing using resin [4] after cleansing and phosphoric acid etching of the fissures.

The present study is focused on protection of tooth surfaces by deposition of flexible quartz (SiOx) thin films by a cold atmospheric plasma jet. Polished and etched enamel slices from the vestibular face of bovine incisor crowns were used. Etching was carried out by means of 37.5 % phosphoric acid gel for 30 s. Plasma jet treatment of these surfaces has been performed: working distance of 4 mm, scan velocity of 1 mm/s, helium flow 1,200 sccm, oxygen flow 15 sccm, helium flow with hexamethyldisiloxane (HMDSO) as precursor for Si 5 sccm, nitrogen flow 1200 sccm, average microwave power 2.6 W, single pulse power 150 W, pulse width 5 µs. The deposited films were analyzed by SEM and Talystep stylus roughness and step height measurements. Further wear resistance tests have been performed using a 10 µm diameter spherical stainless steel indenter with normal forces from 10 to 70 mN, 10 cycles 50 µm travel distance back and forth within 10 s. Deposited SiOx film thickness was measured from 383 nm to 393 nm. Films on polished enamel were destroyed in the wear test with a normal force of 30 mN. The indenter broke through the layer at half of the wear distance, shown in Fig. 1a. The acid pre-etching improves the layer adhesion and stability. The film was stable in the wear test.

a) 

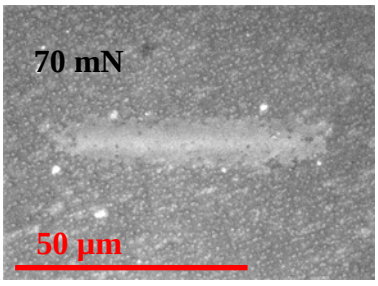
b) 

Figure 1: Results of wear tests a) destroyed SiOx-layer on polished enamel, b) wear resistant SiOx layer skid mark on phosphorus acid pre-etched enamel

SiOx plasma deposition might enable interesting new way for caries prevention. Next we will perform corrosion tests of the SiOx film.

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References

[1] A. Sparavigna, Plasma treatment advantages for textiles, arXiv:0801.3727 (2008).
[2] M. Polak, J. Winter, U. Schnabel, J. Ehlbeck, K.-D. Weltmann, Plasma Process. Polym. (2012), 9.
[3] S. Rupf, A. N. Idlibi, F. Al Marrawi, M. Hannig, A. Schubert, L. von Mueller, W. Spitzer, H. Holtmann, A. Lehmann, A. Rueppell, A. Schindler, PLoS ONE 2011, 6 (10).
[4] M. Hannig, A. Gräfe, S. Atalay, B. Bott, Journal of Dentistry (2004), 32, 75-81