of these films. It was found that 13% N_2 films have the highest hardness, a low coefficient of friction (~0.6), and a reduced wear rate (7.09 $\times$ 10^{-15} m^3/N·m). The discrepancy in the values of CoF is associated with an increased load and a significantly larger contact area in [35]. Wear during AFM tests is overestimated due to high mechanical stresses in the contact associated with the small radius of the tip, wherein AFM-wear makes it possible to accurately determine the difference between all compared coatings.

The used normal forces about 1 μN and a nanoscale radius of the probe (8–76 nm) lead to the creation on the surface of coatings of significant contour pressure (or mechanical stress in contact, contact pressure) of 15–65 GPa. This value is many times higher than the level of contact stresses at macro-tribotests of about 1.3–1.6 GPa. The localization of maximal mechanical stresses at nanometers depth and displacement of the material from the surface by atomic layers gives a different mechanism of the friction process under conditions of microcontact. The high η of Ta coatings allow light moving of atomic layer of materials under the probe acting.

The TaON coatings were chosen according to the strength properties because of the rather high values of H and simultaneously high η and H/E value of 0.08, then according to tribological characteristics—Ta, TaN, and TaON.

4. Conclusions

Nanostructured films of tantalum compounds were deposited on the stainless steel substrates by magnetron sputtering. It was determined that the microstructure of coatings depends on the elemental composition. All tantalum based coatings are characterized by a granular structure. Depending on the composition of the coatings, the grains vary in size from 5 to 20 nm. In some cases (Ta and TaN), the grains associate into cells. All obtained coatings have low roughness values.

The best combination of properties among the studied coatings have TaN (H of 10.0 GPa, E of 158.0 GPa and H/E = 0.06) and TaON (H of 13.3 GPa, E of 157.0 GPa and H/E = 0.08).

The tribological characteristics of obtained coatings were: TaN—CoF of 0.019 in the "sliding" mode and 0.308 in the "plowing" mode, specific volumetric wear of 4.2 $\times$ 10^{-13} m^3/N·m, TaON—CoF of 0.019 in the "sliding" mode and 0.444 in the "plowing" mode, and specific volumetric wear of 6.1 $\times$ 10^{-13} m^3/N·m. Thus, deposition of TaN decreases specific volumetric wear of steel by more than 6 times, TaON—by more than 4 times. These tribological characteristics allow reducing of platelets on the surface of stents, and thereby, preventing the formation of a blood clot.

Thus, TaN and TaON coatings, which have a special complex of mechanical and tribological properties, can be used as upper layer for stainless steel stents.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

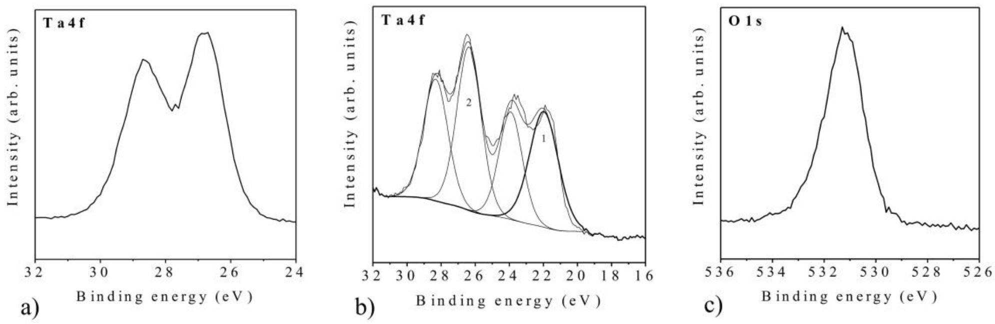

Figure A1. XPS spectra of Ta-based coatings deposited on the steel substrates: Ta^{+5} for Ta_2O_5 (**a**), Ta^{+5} and Ta^0 for Ta/Ta_2O_5 (**b**), O1s for Ta_2O_5 (**c**) [49].

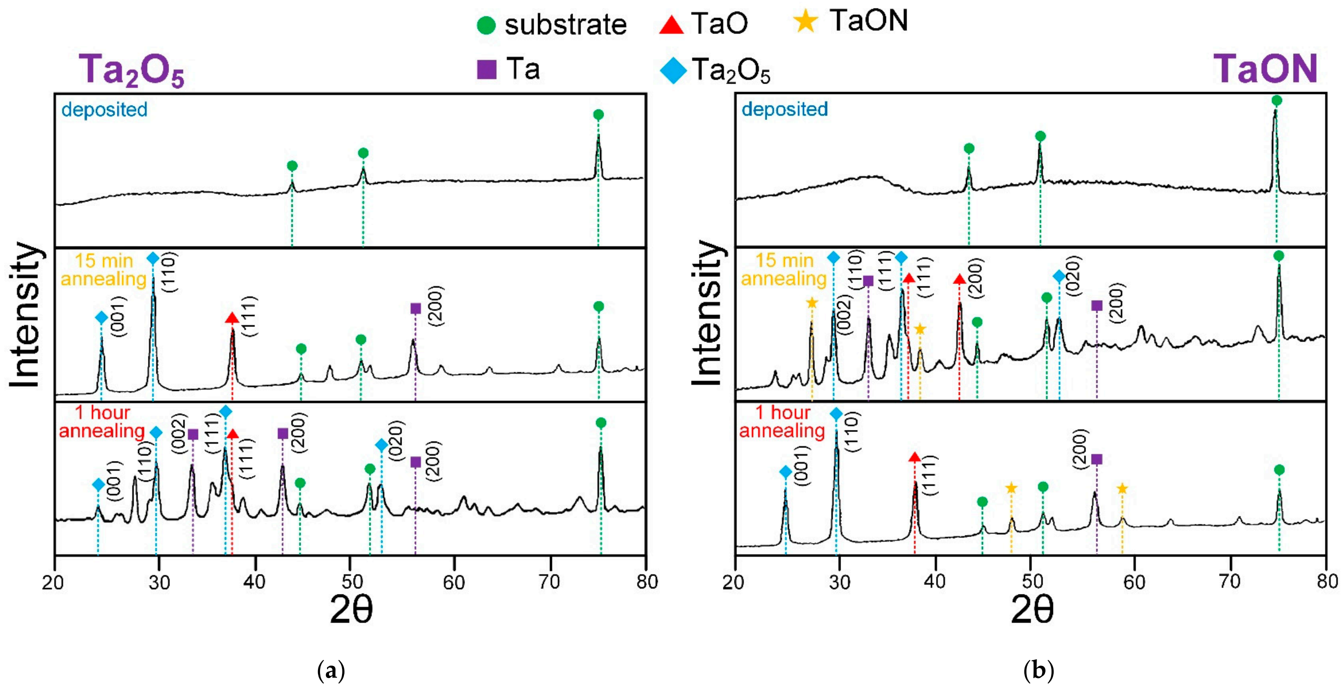

Figure A2. Diffraction X-ray profiles of the Ta_2O_5 (**a**) and TaON (**b**) coatings after application and annealing at a temperature of 973 K for 15 min and 1 h.

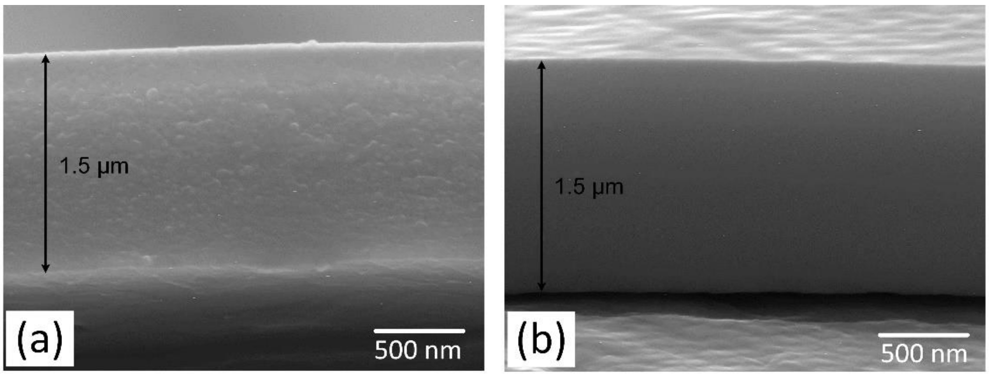

Figure A3. *Cont.*