Contributions on Setting the Optimal Regime of Antibacterial Deposition on the Surface of the Oral Implant of Ti10Zr Bio-alloy

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In order for the implant to exert its antibacterial function in optimal conditions its surface has to be covered with uniformity chemical deposition which confers antibacterial properties. The experiments demonstrated that the most effective forms of the silver which determine the microbial joining are the silver salts and therefore a more uniform coverage of the implant. The paper presents the research results on the chemical deposition conditions of the metallic silver on the Ti10Zr oral implant so as to obtain its optimal behaviour during operation.

Keywords: implant, antibacterial function, silver salts, Ti10Zr oral implant

One of the important roles of an oral implant is that of microbial inhibition for a long time, regardless of the conditions during mastication and outside it.

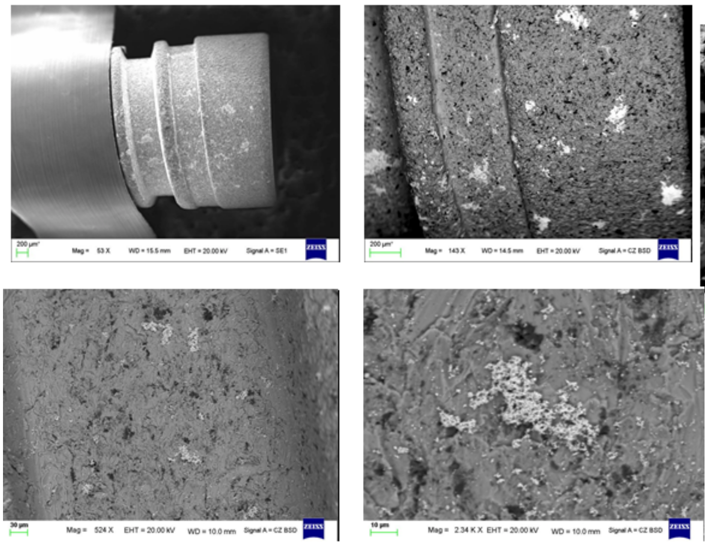
Microbial joining depends essentially on the material from which the oral implant is made and on the conditions in which the implant works. Since the materials used in manufacturing oral implants are expensive and difficult to process, these not being effective in the microbial joining process we cover their surfaces with substances having antioxidant and disinfectant properties. One of these materials with actual use properties is silver [1].

Silver can be used in many ways but it was found experimentally that the most effective forms of silver which may determine the microbial joining are the silver salts [2]. It was demonstrated that the silver nitrate $AgNO_3$ has the highest efficiency because it allows a continuous release of a moderate amount of silver ions and the size and shape of the nanoparticles can be controlled (Pal et al, 2007).

Therefore, the way the surfaces of the Ti10Zr oral implant [3-7] are covered with silver nitrate is essential for its antimicrobial properties over time. The main parameters of technological percentage for the chemical deposition of the metallic silver on the oral implant surfaces are the following: the nature of the solutions in which the implant works, hold time, the temperature during the deposition and the solutions in which the deposition process takes place [8].

Experimental part

That is why, in the paper we made numerous tests on the chemical deposition of the metallic silver on the surfaces of an oral implant immersed in a solution with the Tollens's reagent, by warming the solution at different temperatures, with or without adding formaldehyde in droplets at different intervals time, with a variable hold time. In order to set optimal conditions for the silver chemical deposition there were used several experimental regimes, the implants being placed in a receptacle that contained the Tollens's reagent (the Tollens reagent, was prepared as follows: 100mL of 2% $AgNO_3$ solution was treated with 50 mL of 5% NaOH solution and then the resulting precipitate was dissolved by adding 50 mL of 2% NH_3 solution) [9,10]



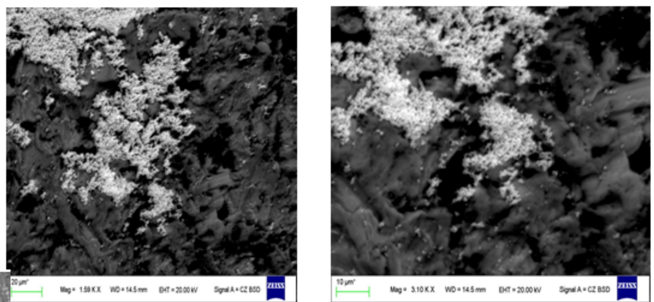


Fig.1. Aspects of the chemical deposition on the Ti10Zr implant of self-screwing and self-drilling screw type obtained by electronic microscopy with electron scanning (SEM); It shows the presence of the metallic silver particles on the whole surface of the implant and the morphology of the particles deposited in the regime: implant immersed in the Tollens's reagent, with heating the solution to 50^0C and adding formaldehyde in droplets every 30 s

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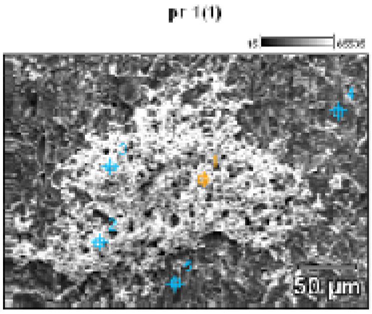


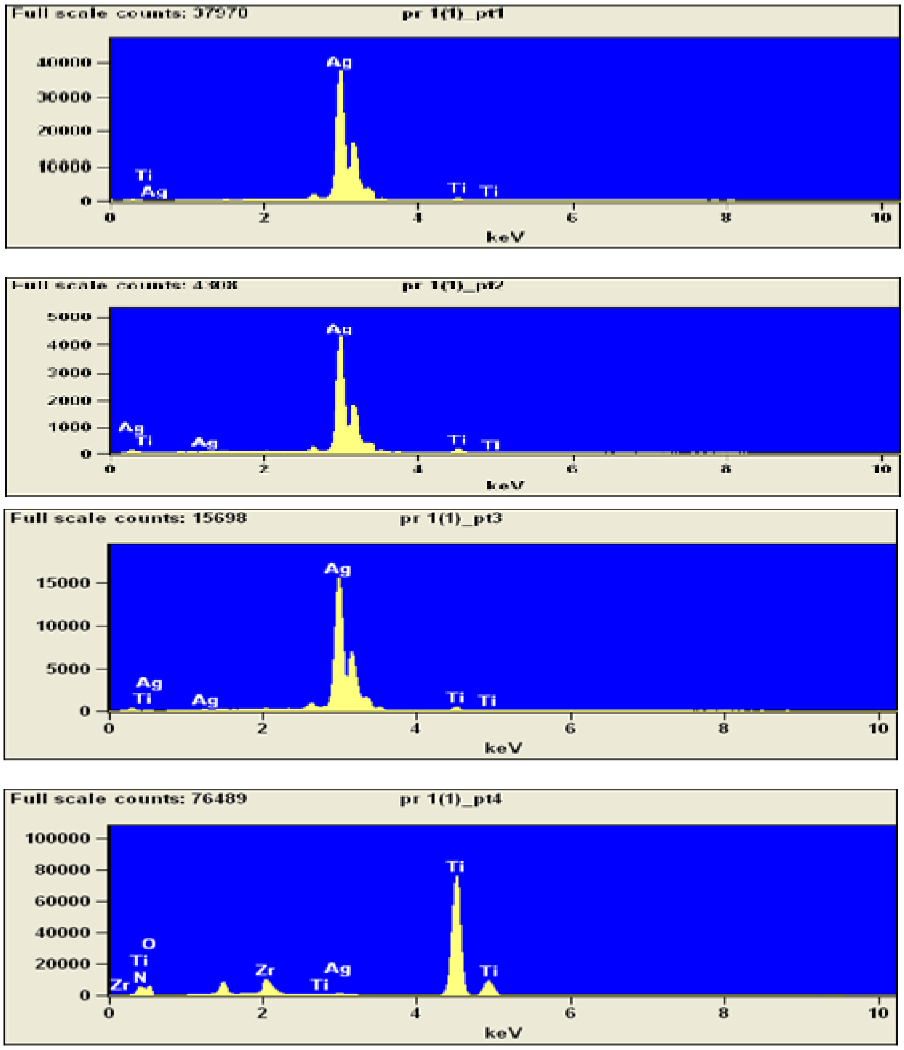
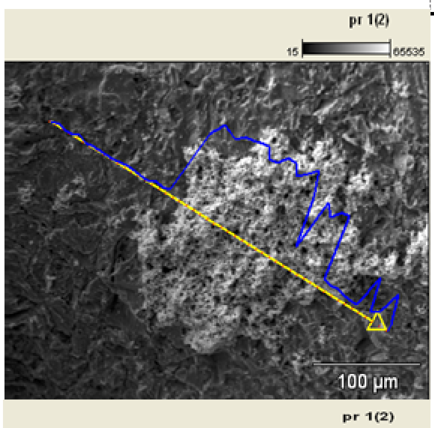


Fig.2. Energy dispersive spectroscopy elemental analysis (EDX) performed on the silver deposition area / implant immersed in the Tollens reagent, with heating the solution to 50^{0}C and adding formaldehyde in droplets every 30 s

Weight %

pr 1(1)_pt1							2.49		97.51
pr 1(1)_pt2							4.03		95.97
pr 1(1)_pt3							2.39		97.61
pr 1(1)_pt4	1.82	8.22	15.04	3.01	0.12	2.91	68.20		0.67
pr 1(1)_pt5							90.12	9.88	



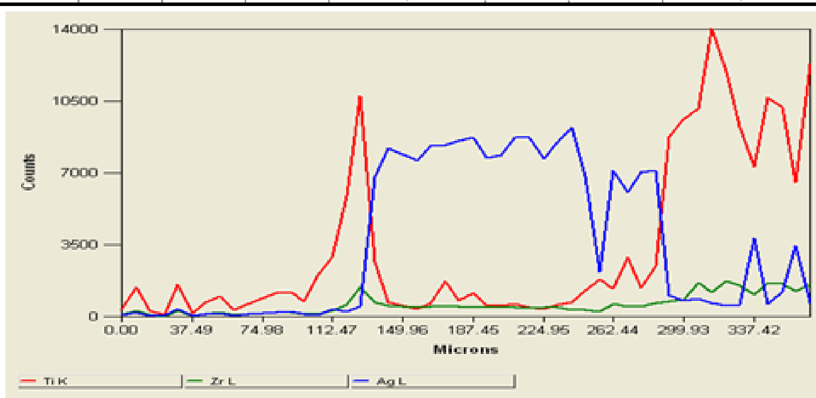


Fig.3. The distribution of the metallic silver (the blue curve) on a diagonal of the deposition area (line scanning) / implant immersed in the Tollens reagent, with heating the solution to 50^{0}C and adding formaldehyde in droplets every 30 s

Highlighting the way in which the chemical deposition of the metallic silver takes place and also the deposition character was done by using electronic microscopy analyses with electron scanning (SEM) (fig. 1, 4) which revealed the presence of the silver on the implant surfaces, the degree of dispersion and the morphology of the silver particles according to the deposition regime and the energy dispersive spectroscopy elemental analysis performed on the silver deposition area (figs. 2, 5-7).

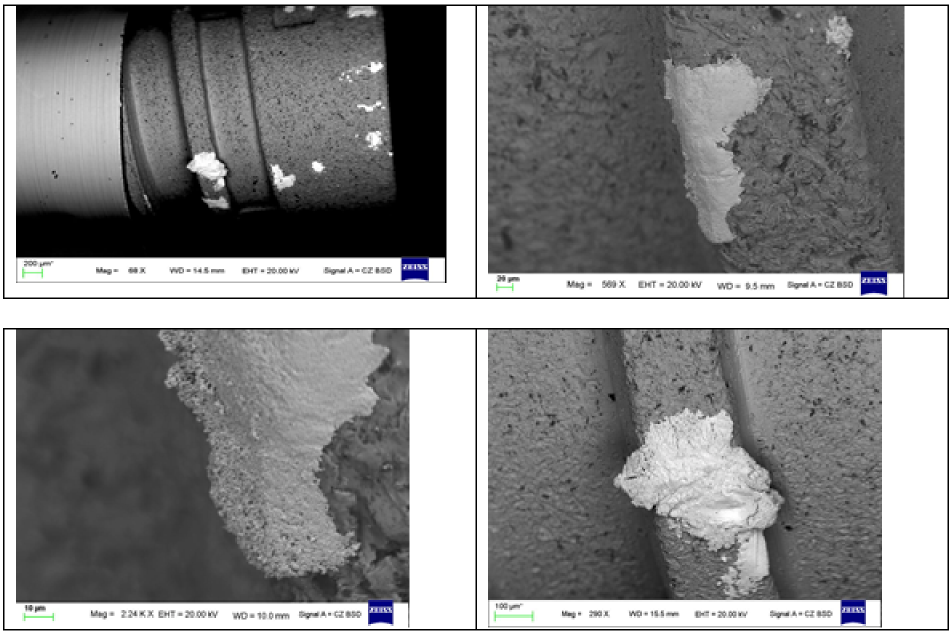
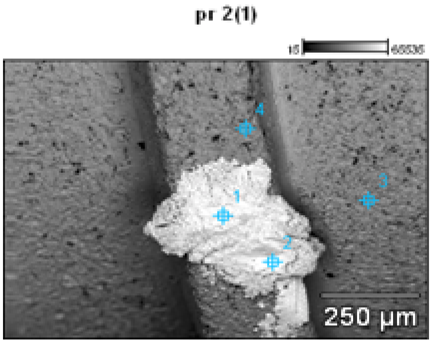


Fig.4. Aspects of the chemical deposition on the Ti10Zr implant of self-screwing and self-drilling screw type obtained by electronic microscopy with electron scanning (SEM); It shows the presence of the metallic silver particles on the whole surface of the implant and the morphology of the particles deposited in the regime: implant immersed in the Tollens reagent, with heating the solution to 70^{0}C and adding formaldehyde in droplets every 30 s



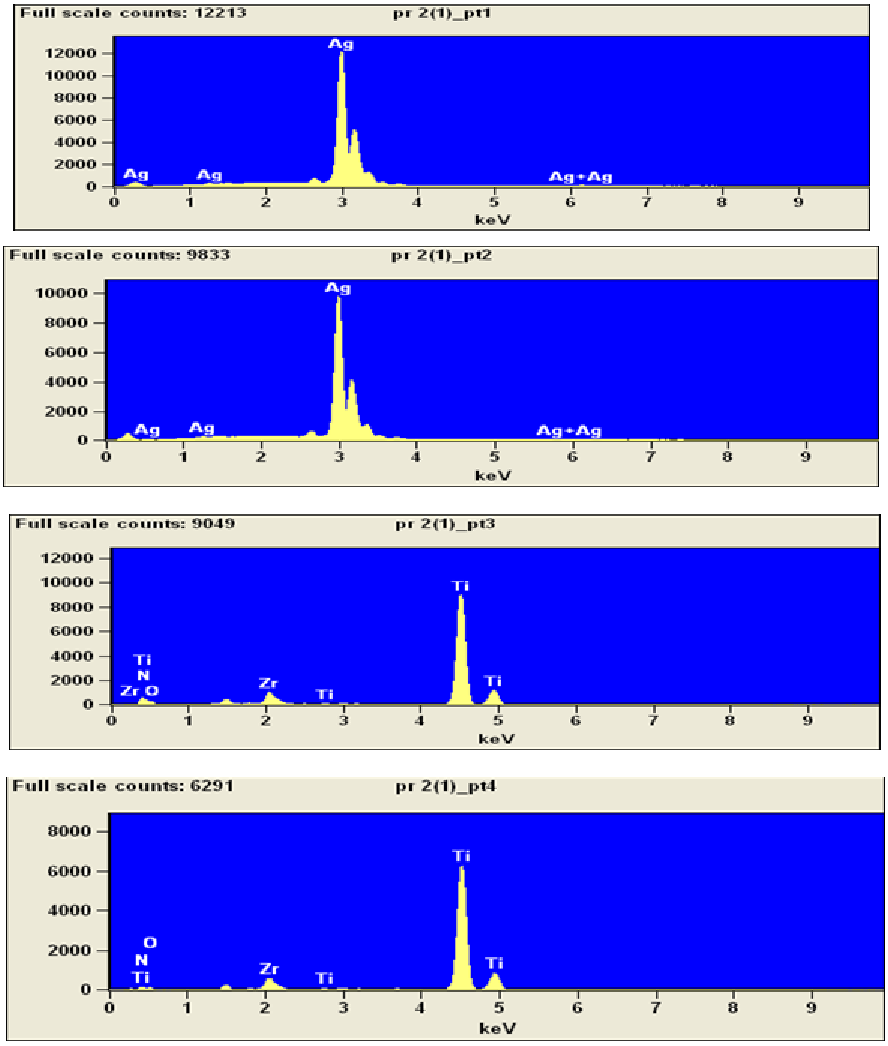


Fig.5. Energy dispersive spectroscopy elemental analysis (EDX) performed on the silver deposition area/ implant immersed in the Tollens reagent, with heating the solution to 70^{0}C and adding formaldehyde in droplets every 30 s/ specimen 2 [1]

pr 2(1)_pt1					100.00
pr 2(1)_pt2					100.00
pr 2(1)_pt3	0.98	5.07	85.06	8.89	
pr 2(1)_pt4	0.00	9.96	82.82	7.22	

Atom %

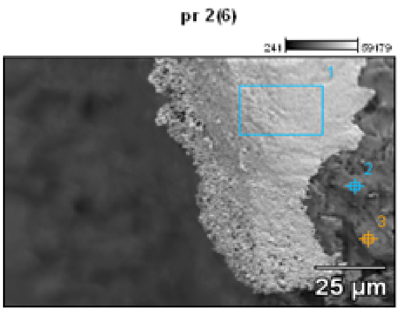
pr 2(1)_pt1					100.00
pr 2(1)_pt2					100.00
pr 2(1)_pt3	3.10	14.02	78.57	4.31	
pr 2(1)_pt4	0.00	25.60	71.14	3.26	

Results and discussions

The experimental results obtained in different conditions of performing the silver chemical deposition on the surfaces of the oral implant of the Ti10Zr bio-alloy are presented in figures 1-7.

- implant immersed in the Tollens reagent, with heating the solution to 50^0C and adding formaldehyde in droplets every 30 s;

- implant immersed in the Tollens reagent, with heating the solution to 70^0C and adding formaldehyde in droplets every 30 s.



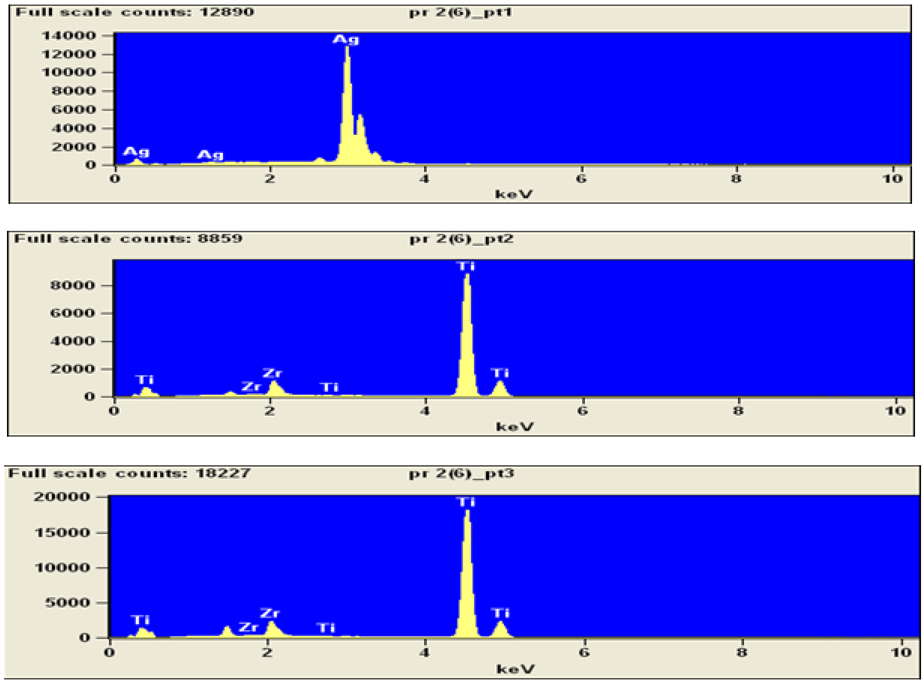


Fig.6. Energy dispersive spectroscopy elemental analysis (EDX) performed on the silver deposition area/ implant immersed in the Tollens reagent, with heating the solution to 70^0C and adding formaldehyde in droplets every 30 seconds/ specimen 2[6]

Atom %

pr 2(6)_pt1			100.00
pr 2(6)_pt2	89.05	10.95	
pr 2(6)_pt3	89.31	10.69	

Weight %

pr 2(6)_pt1			100.00
pr 2(6)_pt2	93.93	6.07	
pr 2(6)_pt3	94.09	5.91	

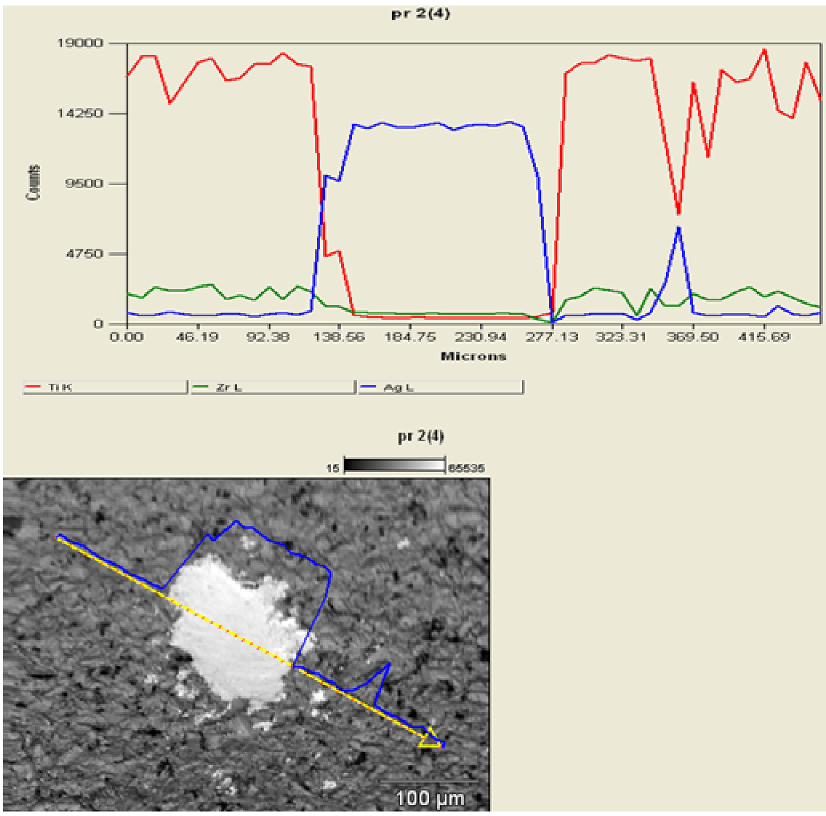


Fig.7. Compact agglomerations with nodule aspect which are well contoured and of high density. The distribution of the metallic silver (the blue curve) on a diagonal of the deposition area (line scanning) / implant immersed in the Tollens reagent, with heating the solution to 70^0C and adding formaldehyde in droplets every 30 seconds specimen 2[4]

Conclusions

The laboratory research results demonstrate the possibility to treat, for antibacterial purpose, the oral implants of the Ti10Zr alloy, in the conditions set experimentally regarding the chemical deposition regime (temperature, hold time in the solution, method of solution preparation) for the oral implants of self-screwing and self-drilling Ti10Zr.

The research on the chemical deposition of the metallic silver confirm the particles presence both in the deposition regimes without heating and with heating the solution to 50 and 70^{0}C respectively and adding formaldehyde in droplets. It was found, however, that on small hold times (5 min) the silver particles are of very small size and have a low degree of dispersion. Also, the heating of the solution to a higher temperature (eg. at 70^{0}C) causes the agglomeration of the particles of large dimensions and with a small dispersion degree which do not cover the implant surface uniformly.

Electronic microscopy analysis with electron scanning (SEM) and the energy dispersive spectroscopic analysis (EDX) showed clearly the presence of the silver in micro-dispersed particles with morphologies and degrees of dispersion dependent strictly on the technological conditions for obtaining the chemical deposition and allow a conclusion on the optimum regime. Small particles in agglomerates in the form of nests, less compact but with a high degree of dispersion, covering uniformly the implant surface are obtained by warming the solution at temperatures of about 50^{0}C with about 10 min holding, with stirring the solution and adding formaldehyde in droplets. The results obtained are encouraging and will continue so as to determine their validity by demonstrating their reproducibility and by establishing correlations between the implant geometry (design) and the optimal conditions for obtaining the chemical deposition.

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