Secure Systems Design and Technology Development. Veliko Tarnovo, Bulgaria
Proceedings of the International Scientific Conference, 2026. Volume II, 385-390

Laser Polished Stainless Steel Use in Food Industry, a Review

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Abstract— Aim of this article is to find and analyze up to date researches about stainless steel polishing using laser, to understand if there is potential for further research to find application of such surface processing technology for food processing equipment. Strict hygiene procedures are necessary to provide food safety, which could be obtained by different methods. Most known and frequently used hygiene methods are washing with water, cleaning solutions and using mechanical devices such as bristles, scrapers and materials such as cloth with paper. In food processing used materials by itself could be self-cleaning, when they have repelling properties (hydrophobic) or are as smooth as possible (polished). Surface condition plays significant role in food safe material hygiene. Rough surface and scratches tend to accumulate residue that is an environment for further microbiological activity. Due to these factors, it is required to produce and maintain smooth surfaces that are in direct contact with food. Since different materials are used in food processing, they have their own role and resistance against scratches and damage. Most commonly used material in food processing nowadays is AISI 304 and 316L grade stainless steel, which have optimal strength, corrosion resistance and durability against scratches. Stainless steel surface for food processing also has to be smooth, in order lower risks of contamination, which is usually obtained by mechanical or electrochemical polishing. Despite complicity and costs of mechanical polishing, this technology is still widely used as it has been established for decades. With development of new technologies, such as laser technologies, new methods of surface treatment are available. Over many years, different researchers have proved, that laser treatment could make surface smoother, creating "polished effect". Laser polishing of stainless steel surfaces could be a solution in future for achieving better hygiene in food processing.

Keywords - stainless steel, laser treatment, surface modification, polishing, food processing industry.

I. Introduction

The most complicated challenge for food processing industry is achieving and maintaining food safety and cleanliness, From beginning of our civilization it is known that depending on food type, its processing method and further storage, changes its shelf life. From the moment of discovering of microbiological life, many new processing methods, such as pasteurization or sterilization, have been implemented to improve food safety and extend shelf life. But not only food itself should be processed, but all other surfaces, that will be in contact with it, must be cleaned or otherwise prepared to lower chances of microbiological or chemical contamination. Very important factor is surface itself, because its condition or specific properties can be favorable for microbiological activity or be destructive to it [1], [2].

Nowadays, mostly used material in food processing, that is in direct contact with food, is AISI 304 or 316 stainless steel. But despite stainless steel universal properties, it should be correctly used and maintained to provide required food safety and hygiene, where most challenging part is preventing biofilm creation or find most efficient way to remove it, using large amounts of water, energy and cleaning chemicals. Despite using automated CIP (clean in place) systems, considerable amounts of resources are still required to achieve required cleanliness [3], [4], [5], [6], [7].

Damaged (scratched, cracked) or rough structure surfaces could be reason for food contact material more intensive corrosion or degradation, that can lead not only to equipment failure, but also contaminate food itself with contact material or its corrosion product residue. Also, surface defects are potential environment for accumulation of organic matter or microbiological contamination. For that reason, surfaces, that are in contact with food, should be as smooth as possible. Surface smoothness could be achieved in many ways, depending on material type and its use conditions [8], [9], [10].

The most convenient method is mechanical or electrochemical polishing, when surface roughness, or smoothness, is between 0.025 µm and 0.2 µm. Such

Online ISSN 3044-7771
https://doi.org/10.68302/std2026.vol2.220

smoothness also provides less friction resistance, improves corrosion resistance and makes surface more light reflective, creating "mirror effect". Also, there also other methods to achieve surface smoothness, such as covering rough base material with "self-leveling" covering substances, or process surface with laser radiation, by melting top layer, creating glazing layer. Also, adding some other antibacterial materials to base material, can improve surface resistance to microbiological activity [11], [12], [14].

In some cases, even rough surfaces, such as hydrophobic ones, could be used to increase water repelling effect, therefore making it more "self cleaning" and theoretically more hygienic. But in practice, hydrophobic surface work only in conditions where air and water are present, otherwise, dry solid substances get stuck in its structure, decreasing surface hydrophobic effect and increasing possibility of microbiological development. Due these disadvantages, such hydrophobic surface could be used only for specific tasks, but not for regular daily use, where polished surfaces are more suitable [14].

II. Polished surfaces in food industry

Main purpose of polished surfaces in food processing equipment is to decrease surface energy, for much easier cleaning of residue and fluid remains. As mentioned before, main challenge for food processing industry, especially in milk processing, is biofilm, that inevitably accumulates on contact surfaces, despite its conditions and properties. But worldwide, researchers are trying to find and implement new technologies in order to decrease accumulation of biofilm or to make it easier to clean it off [15], [16], [17].

Detailed review about surface antibacterial properties by I.Georgakopoulos-Soares et al. [18] shows how different surface types and treatment methods (also mentioning laser treatment) influence on microbiological growth. In the list of different surface textures, there also was a comparison with polished surface, that proved itself more practical in terms of maintaining hygiene, rather than antibacterial surfaces with specific microscopic texture geometry, that could be easily damaged and compromise its functions in daily use.

In A.Avila-Sierra. et al. [19] research abut CIP system cleaning performance depending on surface roughness, findings suggest that smoother stainless steel surfaces tend to show better performance in overall cleanliness, due to less biofilm deposition.

S.Tantratian et al. [20] research about specific bacteria biofilm formation on variety of stainless steel types (304, 316L, 330) with different surface finish (2B, BA) also shows, that that biofilm attaches to any kind of surface finish, but still, it is a bit easier to remove it from more smoother surface. In this case, 2B surface finish is gained during cold rolling, heat treatment with pickling and finishing cold rolling using polished rolls, therefore BA finish is achieved by cold rolling with annealing in protective gas environment, that makes smoother than 2B finish.

Nowadays 3d printing allows to produce objects in small batch or even individual ones with relative low cost, what is favorable in prototyping and specific areas such as medicine (implant creation). In this case, implants usually are made from powder-printed titan alloys or stainless steel, which requires specific finishing, in order to decrease surface roughness but in the same way to create good surface for biocompatibility with patients body. J.Tang et al. [21] research shows, that using anodic oxidation electrochemical polishing, can significantly improve powder-printed stainless steel surface, making it smoother, more robust and giving possibility to controllably create nano-structures, that can act as biocompatible or antibacterial surface. This surface processing method also may be used for such stainless steel surfaces, that are in direct contact with food.

Most challenging areas for maintaining cleanliness and safety in food processing equipment are pipelines, closed tanks and narrow spaces (plate heat exchangers, homogenizers and sprayers). Creating polished surface in these areas are much more complicated, rather than open and easily accessible areas, but is even more important due to higher possibility of biofilm creation, that can lead to clogging and whole system malfunction. For such area treatment, technologies like electrolytic polishing, magnetic abrasive finishing could be used [22], [23], [24].

Despite seemingly smooth looking surface of newly made stainless steel surface or refurbished used one, there still are microscopic defects on the surface, that is one of factors for biofilm forming. As a solution, different kind of substances could be used to cover whole surface area and level out all imperfections and make it very smooth. But as for food processing, such material should be food safe if its particles inevitably get in body thru food. Sol-gel-based surface modification using "Thermolon" (inorganic ceramic polymer) reduces surfaces energy and therefore reduces amount of biofilm formation. Such treatment could be applied evenly throughout all surface, even in narrow and closed one areas. But as D.Z.Liu et al. [24] research shows, despite positive properties of sol-gel-based surface modification, there is discussion of its durability when its used in real life conditions.

On other hand, there are researches, where biofilm is prevented not only buy modified surface texture, but by making surface chemical active. As example, R.K.Rai et al. [26] research proves efficiency of hydantoin based copolymer to destroy biofilm creating microflora with free chlorine molecules, that gets released from copolymer. But such method may be very limited for use in food processing due to contamination of food with coating residue and possibly changing its organoleptic properties.

As an alternative to synthetic coatings, A.Fornés et al. [27] research implements more natural vanillin-functionalized grates, that inhibits certain microflora adhesion to stainless steel surface. This research also has checked difference, when "vanillin" coating was applied on rough (sanded) and polished stainless steel surface, showing, that polished surface in combination with "vanillin" coating performs much better.

In all cases stainless steel surface condition plays significant role in biofilm creation and need of resources and energy to remove or prevent it. Many researches have proven, that polished stainless steel surfaces indeed show better results, but in combination with specific coatings, anti-fouling effect is even more noticeable [28], [29] [30].

From non-biological perspective, polished surfaces are more resistant to physical impacts such as temperature changes, impacts and tend to wear out much less that regular finish or rough surfaced stainless steel due to less possibility of crack appearance [31], [32], [33].

III. Laser radiation made polished stainless steel surface (laser polishing)

Mechanical and electrochemical polishing together with different type of coatings are widely used nowadays in order to prevent biofilm formation on stainless steel surfaces that are used in food processing. As more researches and discoveries appear about surface texture modification by laser treatment, new technologies are implemented in daily use. During last decade, many researches have been made to find technology (parameters of laser use), for achieving “laser polishing”.

Research of C.D.Giorgi et al. [34] used 1064 nm (infrared) 50W Q-switched nanosecond fiber laser to achieve antibacterial surface on 0.3 mm thick cold rolled stainless steel. Different laser parameters (laser pulse energy, scanning speed, protecting gas flow rate and beam movement pattern) were used to find most optimal result to achieve polished surface. Using protective gas environment ensures less surface oxidation and appearance of surface defects.

G.G.Engoor et al. [35] article explores, how laser structuring of stainless steel influences on surfaces biocompatibility or antibacterial ability. Researchers used diode-pumped femtosecond 1030 and 1035 nm fiber lasers to crate different structures (hydrophobic and hydrophilic), while a polished sample was marked as control one. Hydrophilic surface appeared to be most antibacterial due to its specific texture of densely placed small sharp spikes, that rapture cell membranes, destroying bacteria. But there was no research, to test laser modified surface in long term, to check biofilm appearance intensity and structure durability.

J.Outón et al. [36], [37] also studied laser modified stainless steel surface interaction with microflora in order to create bacteria-repellent surface. Researchers used YB-based 40 W solid-state pulsed 1030 nm laser in pulse duration range from 220 femtoseconds to 10 picoseconds which was equipped with harmonic generator, that produces 343 nm wavelength laser beam, that was used for stainless steel surface treatment. Their results show that even with UV range laser, it is possible to create antimicrobial surfaces, that could be implemented in medicine or food processing. Also, its very likely to create polished surface using same laser system, but altering treatment parameters.

Detailed research about laser polishing of stainless steel was made by E.Liu et al. [38], where authors explained principles that leads to creation of polished surface on AISI 316L stainless steel. Nanosecond pulsed 1064 nm 1KW laser system with 2d scanning galvanometer and protective gas device was used to perform experiments on 316L stainless steel, that were sanded with 600 grid sandpaper to create similar roughness specimens. Using different processing strategies and laser parameters, noticeable results were achieved, that could be used as a basis for further experiments.

TABLE I. Laser processing parameters used for obtaining polished surface on AISI 316L stainless steel (1)

Laser processing parameters used for obtaining polished surface on AISI 316L stainless steel (1)			
Parameter	***Reference***		
	[38]	[34]	own
Laser type	Solid-state, 1064 nm	Q-Switched fibre, 1064 nm	Q-Switched fibre, 1064 nm
Power or fluence	1 KW, 3.82 J/cm2	50 W	70% from 20 W
Spot size	1 mm (defocused)	39 μm	40 μm
Scan distance or overlap factor	92 %	10 μm	~90%
Scan speed	700 mm/s	400 mm/s	1700 mm/s
Pulse time	100 ns	40 ns	14 ns
Rate	10 kHz	65 kHz	32 kHz

Fig. 1. Laser polished surface reflection of titanium alloy (left-bottom) and AISI 316L stainless steel (top right) samples

Using gained experience during experiments of laser treatment of titanium alloy surfaces, article author have discovered optimal parameters for creating polished surfaces using accessible q-switched fiber 1064 nm ROFIN F20 laser system with “auto focus” sample table [38], [39], [40]. Same treatment parameters were used on AISI 316L stainless steel, which also created “mirror effect” surfaces “Fig.1”. Varying laser parameters, many surface samples were obtained, which were examined using Olympus Lext OLS5000 3d measuring laser microscope.

Best visually looking samples, which appear as more reflective, have smoother surface texture in comparison with untreated surface, due to melting of uneven rough structure, making it homogenous and smoothed out “Fig.2”. It is of no small importance to compare spent amount of time and energy creating usable surfaces for food processing, where hydrophobic/hydrophilic structure require considerably more energy and time, rather than polished surface [14].

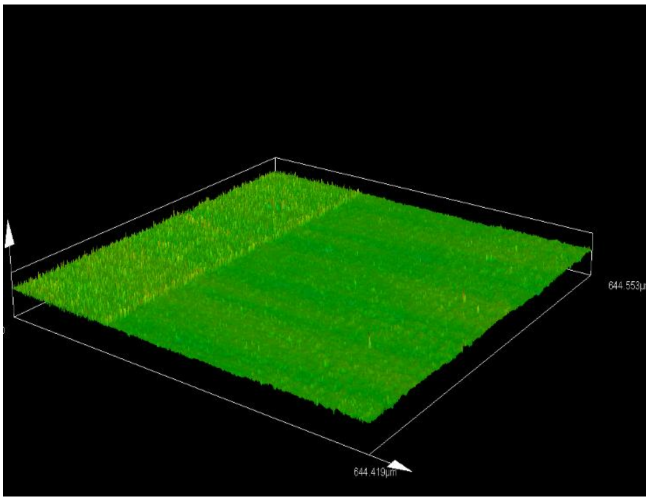

Fig. 2. Comparison of untreated (left) and “laser polished” surfaces (right)

IV. Conclusions

From authors years long experience in milk processing and reviewed scientific articles about stainless steel surface influence on food safety, biofilm creation and methods to remove it, it is clear, that polished surfaces still remain most optimal solution for food industry or medicine. Specifically, modified surfaces like hydrophobic or hydrophilic ones have some certain advantages in terms of antibacterial or self-cleaning effect, but are inferior to polished surfaces due to fragility and high cost in terms of spent energy and time to create such specific surface structures. Despite variety of existing surface polishing methods, laser polishing has great potential to be a cheap and effective alternative. Although polished surface has no antibacterial or water/dirt repelling effect, but still it has lower surface energy in comparison to regular stainless steel factory finish, so less amount of residue can stick on surface. But in combination with different coatings, and polished stainless steel as a base, it is possible to achieve good results, creating very effective surfaces, that prevent biofilm creation or have active antibacterial effect. Further researches of laser polished stainless steel should be made, exposing it to real life use in food processing, testing surfaces durability and interaction with different types of food and their ingredients.

Acknowledgment

This study was made possible through Project Nr. 5.2.1.1.i.0/2/24/I/CFLA/003 “Implementation of consolidation and management changes at Riga Technical University, Liepaja University, Rezekne Academy of Technology, Latvian Maritime Academy and Liepaja Maritime College for the progress towards excellence in higher education, science and innovation” funded by European Union Recovery and Resilience Facility (grant No. C4835.Dok.1109 (P012.0113.02.13.19.04)).

The authors acknowledge the assistance of Dr. Lyubomir Lazov for providing useful information and supporting experiments [41], [42], [43], [44], [45], [46], [47], [48], [49], [50], [51], [52]. Also, local milk processing plant JSC “Latgales piens” for providing “real life” exerience and supporting experiments.

References

[1] X.Tian, T.Li, Y.Liu, Y.Tian, Z.Li, Y.Wang, Y.Ma, Yu Li, X.Wang, W.Wang. Based on surface roughness and hydrophobicity to reduce the bacterial adhesion to collagen films for the ability to enhance the shelf life of food. Food Packaging and Shelf Life. Volume 48, March 2025, 101473.

[2] C.Turpín, A.Doménech-Sánchez. Biofilms formed by human skin microbiota on stainless steel surfaces: implications for pathogen control in food environments. Applied Food Research. Volume 6, Issue 1, June 2026, 101963.

[3] G.Li, L.Tang, X.Zhang, J.Dong. A review of factors affecting the efficiency of clean-in-place procedures in closed processing systems. Energy. Volume 178, 1 July 2019, p. 57-71.

[4] W.Kim, H.Huellemeier, D.R.Heldman. Recovery of cleaning agents from clean-in-place (CIP) wastewater using nanofiltration (NF) and forward osmosis (FO). Journal of Water Process Engineering. Volume 53, July 2023, 103617.

[5] X.Wang, V.M.Puri, A.Demirci, R.E.Graves. Mathematical modeling and cycle time reduction of deposit removal from stainless steel pipeline during cleaning-in-place of milking system with electrolyzed oxidizing water. Journal of Food Engineering. Volume 170, February 2016, p. 144-159.

[6] A.E.Guerrero-Navarro, A.G.Ríos-Castillo, C.Ripolles Avila, A.S.Hascoët, X.Felipe, J.J.Rodriguez Jerez. Development of a dairy fouling model to assess the efficacy of cleaning procedures using alkaline and enzymatic products. LWT. Volume 106, June 2019, p. 44-49.

[7] P.M.Tomasula, W.C.F.Yee, A.J.McAloon, D.W.Nutter, L.M.Bonnaillie. Computer simulation of energy use, greenhouse gas emissions, and process economics of the fluid milk process. Journal of Dairy Science. Volume 96, Issue 5, May 2013, p. 3350-3368.

[8] Z.Hua, M.Zhu. Unlocking the Hidden Threat: Impacts of Surface Defects on the Efficacy of Sanitizers Against Listeria monocytogenes Biofilms on Food-contact Surfaces in Tree Fruit Packing Facilities. Journal of Food Protection. Volume 87, Issue 2, February 2024, 100213.

[9] M.Atapour, I.O.Wallinder, Y.Hedberg. Stainless steel in simulated milk and whey protein solutions – Influence of grade on corrosion and metal release. Electrochimica Acta. Volume 331, January 2020, 135428.

[10] M.Jimenez, G.Delaplace, N.Nuns, S.Bellayer, D.Deresmes, G.Ronse, G.Alogaili, M.Collinet-Fressancourt, M.Traisnel. Toward the understanding of the interfacial dairy fouling deposition and growth mechanisms at a stainless steel surface: A multiscale approach. Journal of Colloid and Interface Science. Volume 404, 15 August 2013, p. 192-200.

[11] L.Nan, K.Yang, G.Ren. Anti-biofilm formation of a novel stainless steel against Staphylococcus aureus. Materials Science and Engineering: C. Volume 51, 1 June 2015, p. 356-361.

[12] I. Ostrov, I. Polishchuk, M. Shemesh, B. Pokroy, Superhydrophobic Wax Coatings for Prevention of Biofilm Establishment in Dairy Food. ACS Applied Bio Materials. 2019, 2, 11, pp. 4932–4940.

[13] N.Rungraeng, Y-C.Cho, S.H.Yoon, S.Jun. Carbon nanotube-polytetrafluoroethylene nanocomposite coating for milk fouling reduction in plate heat exchanger. Journal of Food Engineering. Volume 111, Issue 2, July 2012, p. 218-224.

[14] A.Abolins. Potential Laser Processing Parameters for Obtaining Milk Repelling Surface on Stainless Steel (AISI 316L). Environment. Technology. Resources. June 2025. Volume IV, p. 453-457.

[15] C.Rubio, D.Costa, M.N.Bellon-Fontaine, P.Relkin, C.M.Pradier, P.Marcus. Characterization of bovine serum albumin adsorption on chromium and AISI 304 stainless steel, consequences for the Pseudomonas fragi K1 adhesion. Colloids and Surfaces B: Biointerfaces. Volume 24, Issues 3–4, April 2002, p. 193-205.

[16] M.N.Leclercq-Perlat, M.Lalande. Cleanability in relation to surface chemical composition and surface finishing of some materials commonly used in food industries. Journal of Food Engineering. Volume 23, Issue 4, 1994, p. 501-517.

[17] O.M.Magens, J.F.A.Hofmans, Y.Adriaenssens, D.I.Wilson. Comparison of fouling of raw milk and whey protein solution on stainless steel and fluorocarbon coated surfaces: Effects on fouling performance, deposit structure and composition. Chemical Engineering Science. Volume 195, February 2019, p. 423-432.

[18] I.Georgakopoulos-Soares, E.L. Papazoglou, P.Karmiris-Obratański, N.E.Karkalos, A.P.Markopoulos. Surface antibacterial properties enhanced through engineered textures and surface roughness: A review. Colloids and Surfaces B: Biointerfaces. Volume 231, November 2023, 113584.

[19] A.Avila-Sierra, Z.J.Zhang, P.J.Fryer. Effect of surface characteristics on cleaning performance for CIP system in food processing. Energy Procedia. Volume 161, March 2019, p. 115-122.

[20] S.Tantratian, N.Srimangkornkaew, C.Prakitchaiwattana, R.Sanguandeekul. Effect of different stainless steel surfaces on the formation and control of Vibrio parahaemolyticus biofilm. LWT. Volume 166, August 2022, 113788.

[21] J.Tang, S.Li, Y.Liu, G.Pei, M.Yan. Significantly enhanced biocompatibility and performance of 3D-printed porous 316L stainless steel via a simple and efficient surface polishing approach. Materials & Design. Volume 251, March 2025, 113640.

[22] I.Ihara, E.Nakano, E.McLamore, J.K.Schueller, K.Toyoda, K.Umetsu, H.Yamaguchi. Cleanability of milk deposits on inner stainless steel tubing surfaces prepared by magnetic abrasive finishing. Engineering in Agriculture, Environment and Food. Volume 10, Issue 1, January 2017, p.63-68.

[23] K.Aragaki, I.M.A.Mohamed, H.Fujiwara, M.Farghali, G.Yoshida, I.Ihara, J.K.Schueller, H.Yamaguchi. Reduction of CO2 emission and energy use during cleaning of milk deposits using ultra-smooth stainless tubing. Environmental Challenges. Volume 23, June 2026, 101446.

[24] D.Z.Liu, S.Jindal, J.Amamcharla, S.Anand, L.Metzger. Short communication: Evaluation of a sol-gel–based stainless steel surface modification to reduce fouling and biofilm formation during pasteurization of milk. Journal of Dairy Science. Volume 100, Issue 4, April 2017, p. 2577-2581.

[25] I.Ihara, H.Tokuda, J.K.Schueller, I.M.A.Mohamed, Y.Sakamoto, K.Toyoda, K.Umetsu, H.Yamaguchi. Surface Roughness and Cleanability: Evaluating the Impact of Magnetic Abrasive Finishing on Dairy Equipment. Journal of Food Process Engineering. Volume 48, Issue 4, April 2025, e70106.

[26] R.K.Rai, H.Kanniyappan, V.Muthuvijayan, K.Venkitasamy, A.Jayakrishnan. Durable polymeric N-halamine functionalized stainless steel surface for improved antibacterial and anti-biofilm activity. Materials Advances. Volume 2, Issue 3, February 2021, p. 1090-1098.

[27] A.Fornés, A.R.Soler, S.Ribes, J.M.Barat, É.Pérez-Esteve, P.Soler, R.Salinas, Y.Moreno. Prevention of bacterial adhesion in water conduction systems using vanillin-functionalized grates. Journal of Environmental Chemical Engineering. Volume 12, Issue 5, October 2024, 114122.

[28] A.Ávila-Sierra, Z.J.Zhang, P.J.Fryer. Effect of surface roughness and temperature on stainless steel - Whey protein interfacial interactions under pasteurisation conditions. Journal of Food Engineering. Volume 301, July 2021, 110542.

[29] S.Jindal, S.Anand, K.Huang, J.Goddard, L.Metzger, J.Amamcharla. Evaluation of modified stainless steel surfaces targeted to reduce biofilm formation by common milk sporeformers. Journal of Dairy Science. Volume 99, Issue 12, December 2016, Pages 9502-9513.

[30] J.F.Frank, R.Chmielewski. Influence of Surface Finish on the Cleanability of Stainless Steel. Journal of Food Protection. Volume 64, Issue 8, 1 August 2001, p. 1178-1182.

[31] M.Kořenek, T.Ivanova, V.Heger, K.Dočkal, Miroslav Mashlan. Impact of surface roughness and additive manufacturing-induced structural defects on oxidation of 316L stainless steel. Journal of Materials Research and Technology. Volume 39, December 2025, p. 6823-6834.

[32] F.Ottenklev, M.Adell, D.Orlov. Non-monotonic evolution of surface roughness in a stainless steel during cold deformation. Materials Science and Engineering: A. Volume 799, January 2021, 140150.

[33] S.M.Jafarpour, C.Menegus, M.Bolan, S.Mändl, S.Martin, A.Dalke, C.Cancellieri, A.Leineweber, L.P.H.Jeurgens, H.Biermann. Investigation of changes in surface characteristics of AISI 316L stainless steel induced by different surface activation types in correlation with the surface finishing state. Surfaces and Interfaces. Volume 78, December 2025, 108150.

[34] C.D.Giorgi, V.Furlan, A.Gökhan.Demir, E.Tallarita, G.Candiani, B.Previtali. Laser Micro-polishing of Stainless Steel for Antibacterial Surface Applications. Procedia CIRP. Volume 49, 2016, Pages 88-93.

[35] G.G.Engoor, S.Selvaraj, N.Acharya, V.Muthuvijayan, S.Krishnan, S.N.Unni, N.J.Vasa. Laser polarization induced surface structuring of 316L stainless steel and influence on biocompatibility and antibacterial performance. Results in Surfaces and Interfaces. Volume 19, May 2025, 100547.

[36] J.Outón, M.Carbú, M.Domínguez, J.J.Delgado, V.Matres, E.Blanco. IPSS: A promising strategy for the generation of effective bacteria-repellent surfaces. Surfaces and Interfaces. Volume 57, January 2025, 105780.

[37] J.Outón, M.Carbú, M.Domínguez, M.Ramírez-del-Solar, G.Alba, M.Vlahou, E.Stratakis, V.Matres, E.Blanco. Size matters: how periodicity and depth of LIPSS influences E. coli adhesion on ferritic stainless steel. Applied Surface Science. Volume 663, August 2024, 160225.

[38] E.Liu, X.Chen, Y.Jin, Y.Chen, J.Xu, D.Shan, B.Guo. Surface morphology evolution and tribological behavior in nanosecond pulsed laser polishing of S136 mold steel. Journal of Materials Research and Technology. Volume 22, February 2023, p. 3230-3244.

[39] A.Abolins, A.Aversa, Y.Dekhtyar, M.Dortins, M.Gorohovs, G.Khroustalyova, L.Lazov, A.Mamajevs, M.A.H.Olaish, A.Rapoport, E.Skrebele, H.Sorokins, E.Sprudzs. Electrical Potential and Cell Immobilisation Capacity of a Laser-Treated Titanium Alloy Surface. Materials (Basel). March 2026, 19(6):1051.

[40] L.Lazov, L.Linkov, N.Angelov, E.Sprudzs, A.Abolins. A Predictive Model and Comparative Analysis of Laser-Induced Phase Transition Thresholds for Four Key Engineering Alloys. Materials (Basel). February 2026, 19(5):927.

[41] L. Lazov, H. Deneva, P. Narica, "Factors influencing the color laser marking" Vide Tehnologija Resursi Environment Technology ResourcesOpen source preview, 2015, 1, p. 102–107.

[42] L. Lazov, P. Narica, J. Valiniks, H. Deneva, D. Klavins, "Optimization of CO2 laser parameters for wood cutting."Vide Tehnologija Resursi Environment Technology Resources Open source preview, 2017, 3, p. 168–173.

[43] L, Lazov., N. T. Dolchinkov, et al, "Study of laser cutting and marking on the filt with the help of a CO2-laser", Vide Tehnologija Resursi Environment Technology ResourcesOpen source preview, 2019, 3, p. 143–14.

[44] I. Balchev, A. Atanasov, A. Lengerov, L. Lazov, L., "Investigation of the influence of the scanning speed and step in laser marking and engraving of aluminum", Journal of Physics Conference Series Open source preview, 2021, 1859(1), 01200.

[45] L. Lazov, E. Teirumnieks, I. Draganov, N. Angelov, „Numerical modeling and simulation for laser beam welding of ultrafine-grained aluminium", Laser Physics Open source preview, 2021, 31(6), 066001.

[46] L. Lazov, T. Karadzhov, „Methods for measuring laser power", Vide Tehnologija Resursi Environment Technology ResourcesOpen source preview, 2021, 3, p. 173–180.

[47] L.Lazov, A.Snikeris, , I.Balchev, E.Teirumnieks, E., „Laser marking and engraving of household and industrial plastic products", Journal of Physics Conference SeriesOpen source preview, 2021, 1859(1), 012016.

[48] L. Lazov, E. Teirumnieks, I. Draganov, N. Angelov, „Numerical modeling and simulation for laser beam welding of ultrafine-grained aluminium", Laser Physics Open source preview, 2021, 31(6), 066001.

[49] I. Balchev, A. Atanasov, A. Lengerov, L. Lazov, L., "Investigation of the influence of the scanning speed and step in laser marking and engraving of aluminum", Journal of Physics Conference Series Open source preview, 2021, 1859(1), 01200

[50] R.S.Ghalot,L. Lazov, E. Yankov, N. Angelov, "Investigation of the Change in Roughness and Microhardness during Laser Surface Texturing of Copper Samples by Changing the Process Parameters." Coatings 2023, 13, 1970.

[51] Lazov L., Dolchinkov N., Shterev Y., Lilianova St., Pacejs Anton, Use of CO_2 laser for marking and clearing of textile materials for manufacture of military equipment, 12th International Scienfic and Practical conference Environment. Technology. Resources. ISBN 1691-5402, Vol 3, 20-22.06.2019. Rezekne, pp. 32-36

[52] Dolchinkov N., Lazov L., Shterev Y., Boganova D., Peneva M., Study of laser cutting and marking on the filt with the help of a CO_2-laser, 12th International Scienfic and Practical conference Environment. Technology. Resources. ISBN 1691-5402, Vol 3, 20-22.06.2019q Rezekne, Latvia, pp. 143-147