Corrosion mechanism in laser melted layers of austenite stainless steel in Ringer solution

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Abstract

Statement of the Problem: Austenite stainless steels were first used for the manufacture of implants due to their high corrosion resistance and good mechanical properties. In recent years, different laser technologies such as laser cutting, selective laser melting, laser welding and laser heat treatment have been widely implemented in the production of various types of implants. However, application of these technologies leads to microstructural transformations in the treated surface layer, which can change the corrosion resistance and mechanical properties. The aim of the present study is to investigate the mechanism of corrosion destruction in laser-melted layers of AISI 321 austenitic stainless steel (ASS) in Ringer solution. The ASS surface was melted by continuous CO_2 laser. The melted surfaces was subjected to electro-chemical tests in Ringer solution. The destruction of the laser-melted layers was investigated by OM, SEM and EDX analysis. It was established that the main corrosion mechanism in the laser-melted layers of AISI 321 austenitic stainless steel is selective destruction of the corrosion nonresistant δ-ferrite phase in the form of pitting. As a result, round-shaped pittings with sizes of 10 - 400 μm and depth of 40-100 μm are formed uniformly on the melted surface. The corrosion mechanism in the laser-melted layers consists of the following stages (Fig. 1): 1) destruction of δ-ferrite and network of austenite dendrites (Fig. 1b); 2) fracture of the austenite dendrites and pitting formation (Fig. 1b) and 3) round-shaped pitting with rough surfaces (Fig. 1c).

Conclusion & Significance: From the point of view of corrosion destruction, laser melting of the surface of AISI 321 austenitic stainless steel is favorable for the durability of the implant’s construction.

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Image

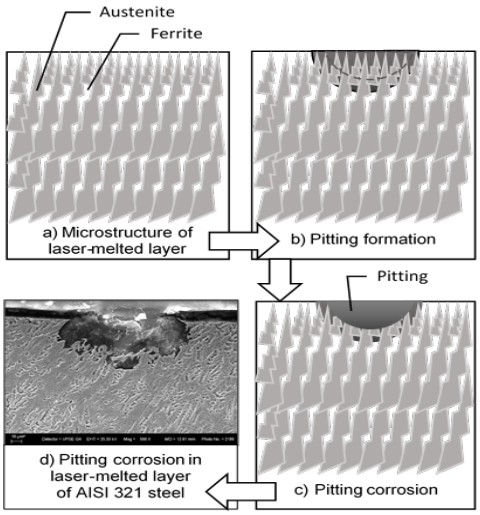

Fig. 1 Mechanism of selective corrosion of a laser-melted layer of AISI 321 steel.

Recent Publications

1. Panova, N. K., Nikolova, K. T., & Dikova, T. D. (2023). Application of lasers and laser processing technologies in modern dentistry: A review. Journal of Chemical Technology and Metallurgy, 58(6), 1116-1127.
2. Dobrzański, L. A., & Dobrzańska-Danikiewicz, A. D. (2019). Applications of laser processing of materials in surface engineering in the industry 4.0 stage of the industrial revolution. Materials Performance and Characterization, 8(6), 1091-1129.
3. Stavrev, D., Dikova, T. D., Shtarbakov, V., & Milkov, M. (2011). Laser surface melting of austenitic Cr-Ni stainless steel. Advanced Materials Research, 264, 1287-1292.
4. Tiwari, S., & Mishra, S. B. (2018). Corrosion of Stainless Steel and its Prevention through Surface Modification for Biomedical Application: A Review. Asian Journal of Engineering and Applied Technology, 7(S2), 60-66.
5. Siva Sundaram, C., Gokulraj, K., Hari Vignesh, N., et al. (2022). Biocorrosion Studies on Stainless Steel Implant Material with Different Surface Process Condition. In Materials, Design and Manufacturing for Sustainable Environment: Select Proceedings of ICMDMSE 2022 (pp. 57-65). Singapore: Springer Nature Singapore.

Photograph

Biography

PhD Ivaylo Dianov Parushev is a chief assistant professor in the Department "Clinical Medical Sciences" at Faculty of Dental Medicine, Medical University of Varna, Bulgaria. Dr Parushev has more than 40 scientific papers published in Bulgarian and English in scientific journals and conferences' proceedings. He has participated in more than 20 national and international congresses and conferences. His scientific interest are in the field of biomaterials, dental materials, metallography, bone scaffolds, dental implants and undecalcified bone histology.

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