On the influence of laser treatment on high-temperature oxidation of titanium alloys by taking advantage of the effect of nitrogen in the surface region.

Titanium and its alloys are promising alternatives for materials currently applied in high-temperature applications, such as aircraft engines, car engines, or gas turbines. Nowadays, parts of aircraft engines are commonly made of nickel- or iron-based alloys, however, their density is almost twice that of titanium and its alloys [1]. **The problem identified to be solved** is the need to improve the high-temperature oxidation resistance of currently exploited Ti-based materials to reduce the weight of *i.e.* aircraft components or gas turbines. Today, new methods allowing to increase the oxidation resistance have been developed, with special attention to **surface treatments**.

In the temperature range of 600-900°C titanium oxidation is mainly governed by the dissolution of oxygen in the metallic substrate. The key role during the oxidation of Ti and its alloys in the air atmosphere plays nitrogen since it creates a well-defined N-rich layer between the oxide and the matrix, which slows the diffusion of oxygen into the metal. **The intended insertion of nitrogen into the surface region of titanium and its alloys could effectively improve its resistance to high-temperature oxidation.** The powerful techniques that contribute to the increase in nitrogen in the surface region are laser treatments [2–5]. Therefore, t**he overall objective of this project is to improve the high-temperature oxidation resistance of multicomponent titanium alloys (TIMETAL 834 and TIMETAL XT) by laser surface treatments which induce the formation of Ti(O,N) surface layer on top of laser-treated titanium. This surface layer potentiates the beneficial effect of atmospheric nitrogen to slow down the high-temperature oxidation of titanium.** Recent reports reveal that surface treatment that has been proven to improve titanium high-temperature oxidation resistance is laser shock peening (LSP) [1,6,7], therefore in this project, LSP treatment will be used as a reference for conventional laser treatments.

Over the last 30 years, high-temperature titanium alloys have been limited to the known compositions broadened by the solubility limits and precipitation ability. The development of titanium alloys led to the development of advanced high-temperature systems such as TIMETAL 834 or TIMETAL XT, containing elements strongly improving high-temperature oxidation resistance, such as Si, Al, and Sn. According to the literature silicon [8,9] is an essential element in high-temperature titanium alloys, since it creates Ti-Si precipitates. **However, during laser treatment, all alloying elements can react with air components and form phases that are more thermodynamically stable in addition to titanium [4], resulting in improved resistance to high-temperature oxidation. This is an important issue for multi-component titanium alloys.** This project will provide insight into the surface properties of modern Ti-based materials after laser treatment (roughness, chemical composition, microstructure, and mechanical properties) and analysis of their influence on high-temperature oxidation resistance.

The work carried out in the submitted project has fundamental importance for determining the interaction of the laser beam with the surface of novel Ti-based substrates and its influence on the high-temperature oxidation resistance. The acquired knowledge will be important not only from the point of view of the high-temperature application but will also contribute to the conscious use of laser modification of titanium and its alloys.

[1] L. Lavisse, P. Berger, A. Kanjer, V. Optasanu, C. Gorny, P. Peyre, M. François, T. Montesin, M.C. Marco de Lucas, Corros. Sci. 197 (2022) 110080.

[2] F. Torrent, L. Lavisse, P. Berger, J.M. Jouvard, H. Andrzejewski, G. Pillon, S. Bourgeois, M.C. Marco De Lucas, Appl. Surf. Sci. 278 (2013) 245–249.

[3] F. Torrent, L. Lavisse, P. Berger, G. Pillon, C. Lopes, F. Vaz, M.C. Marco de Lucas, Surf. Coatings Technol. 255 (2014) 146–152.

[4] D. Kuczyńska-Zemła, P. Kwaśniak, A. Sotniczuk, T. Boll, D. Chassaing, P. Bazarnik, P. Wieciński, M. Pisarek, R. Ostrowski, H. Garbacz, Appl. Surf. Sci. 614 (2023) 156211.

[5] D. Kuczyńska-Zemła, G. Sundell, M. Zemła, M. Andersson, H. Garbacz, Appl. Surf. Sci. 562 (2021) 150193.

[6] A. Kanjer, L. Lavisse, V. Optasanu, P. Berger, C. Gorny, P. Peyre, F. Herbst, O. Heintz, N. Geoffroy, T. Montesin, M.C. Marco de Lucas, Surf. Coatings Technol. 326 (2017) 146–155.

[7] L. Lavisse, A. Kanjer, P. Berger, V. Optasanu, C. Gorny, P. Peyre, T. Montesin, M.C. Marco de Lucas, Surf. Coatings Technol. 403 (2020) 126368.

[8] E. Zhao, S. Sun, Y. Zhang, J. Mater. Res. Technol. 14 (2021) 3029–3042.

[9] D. Vojtěch, B. Bártová, T. Kubatík, Mater. Sci. Eng. A 361 (2003) 50–57.