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High power femtosecond laser to improve aerodynamic performance

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Abstract

Femtosecond laser now reaching 1 kW of mean power can be used in laser solutions for aeronautic, allowing consumption reduction. It is indeed known that the drag can be reduced by suited texturation on plane wings. Hybrid Laminar Flow Control (HLFC) uses multiple micro holes drilling. In the frame of the European Project MULTIPOINT, using a kW femtosecond laser, drilling of holes on Titanium with 0.8 mm thickness can be achieved at a drilling speed of 150 holes per second. Riblets are micro grooves engraved in the direction of flow. In the frame of the French Project CHASSEUR, the surfacing speed today near 1 cm^2/min is expected to reach 25 cm^2/min by combining a 300 W fs laser with a spatial shaping of multiple square spots.

Keywords: Femtosecond laser texturing, Riblets, Drilling

Femtosecond lasers are at a turning point in laser processing technologies, which will enable new fields of use and new methods of production.

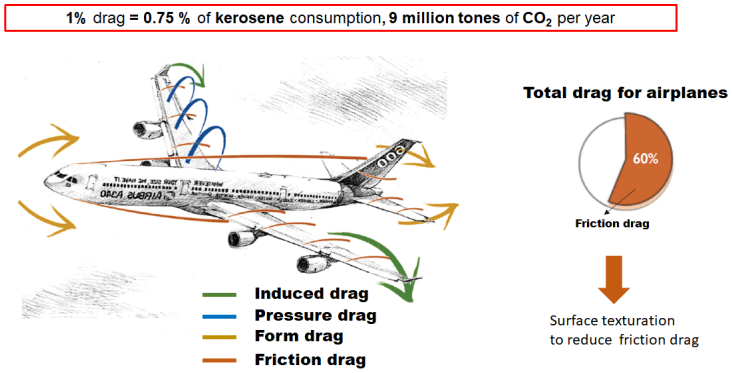

Fig. 1: Visualization of the various drags on a plane, the friction drag being the biggest, and can be reduced by surface texturation.

High mean power up to 1 kW and "agility" of the lasers for process optimization make them relevant tools for flexible, reconfigurable production. At the same time, aircraft technologies need new solutions for the reduction of energy consumption. In this field, a current development aims to improve plane wings aerodynamic performance by the implementation of flow manipulation techniques using micro texturing. The challenge is to realize micro sized structures on very large surfaces. Up to 9% reduction in fuel consumption is expected for intercontinental flights by using such texturing.

Two kinds of structures are studied: Riblets, which are grooves engraved in the direction of flow, allowing the reduction of the aircraft drag, and micro-holes for the manufacture of HFLC (hybrid laminar flow control) structures. The distance between the grooves of riblets and their heights are typically of the order of a few tens of micrometers. HLFC structures are achieved by creating a pattern of millions of micro-holes perfectly aligned with typical pitches from 500 to 700 microns and diameters around 50-100 µm for a sample thickness of 600 to 800 microns.

High power femtosecond lasers combined with beam engineering can answer to this challenge as demonstrated by the collaborative project MULTIPOINT (European project). With the MULTIPOINT prototype a drilling of holes on Titanium with 0.8 mm thickness is demonstrated with a drilling speed of 150 holes per second.

The collaborative project CHASSEUR (French project) also aims to develop a versatile industrial high power femtosecond laser platform capable of delivering the specifications responding to the plane aerodynamic performance enhancement requirements. The first step in the process development is to validate the shape of Riblets structures (with low laser power and small surfaces) and to extent the result to the real sample with the suited laser power. The obtained results show the role of a spatial beam shaping to reach the technical specifications but also the economic objectives, leaded by a required high throughput. The following figure shows the first results with single squared spot machining, and expectation for multi-spots machining.

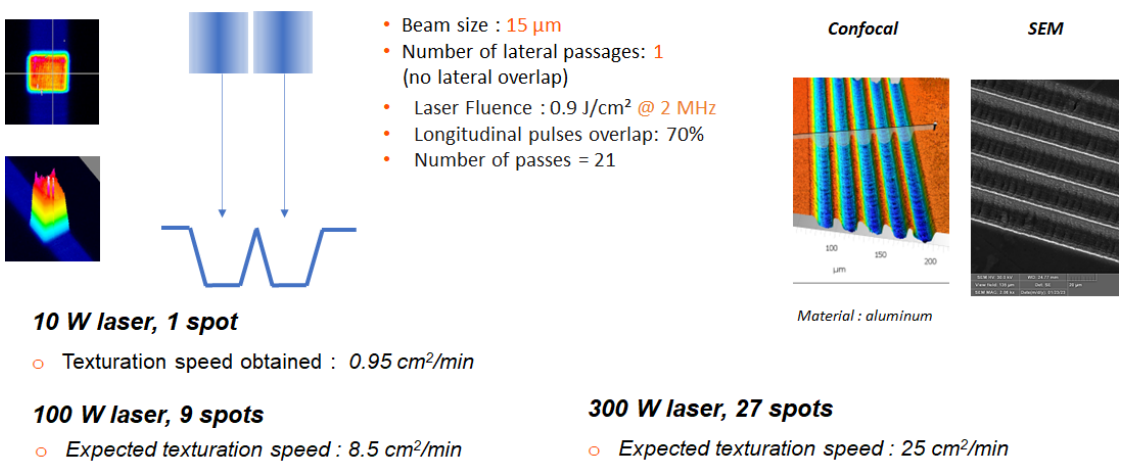

Fig. 2: Riblets texturation of aluminum by square femtosecond beams