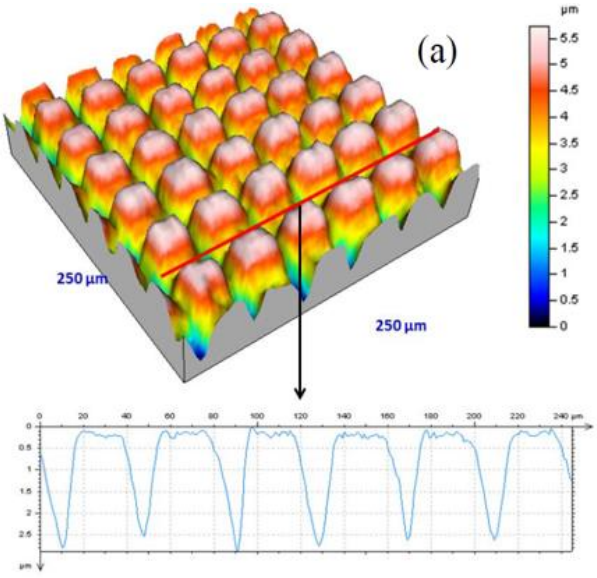
Bruker alicona

Optical Metrology Application Note

Application:

Laser Micro Texturing of materials to improve their tribological properties.



Bruker Alicona is a leading global supplier of optical metrology solutions based on the principle of Focus Variation.

Focus Variation works on the basis of moving a focal plane over a surface and collecting robust 3D data which can then be used to measure geometric form and surface finish from a single optical sensor.

Measurement processes can be fully automated and provide GD&T measurement capabilities across all industrial & medical sectors.

The systems are in use in Industry, Industrial Research, Universities and production facilities globally.

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Introduction

In this application note, we describe the use of Focus Variation for research in µ-mechanics: Bruker Alicona systems help to improve manufacturing processes at the Applied Mechanics Department of the FEMTO-ST Institute in Besançon.

Focus Variation is a high-resolution optical 3D metrology technology developed and commercialized for 20 years by the company Bruker Alicona. In France, the prestigious FEMTO-ST research centre has been using this technology for the past 15 years in its µ-mechanics research. The industrial partners of the applied mechanics department of the institute generally manufacture parts and geometrical details of very small dimensions with adapted microfabrication machine tools and a great know-how, but their control is often problematic. The laboratory's researchers provide them adapted measurement solutions in order to characterize their parts and thus improve their manufacturing processes in the context of collaborative research and development.

Laser Micro-texturing

The improvement of cutting tools and cutting processes is a major research axis of the Applied Mechanics laboratory, and some of the researchers of the Applied Mechanics department of FEMTO-ST are used to work on the micro-texturing of steels and carbides in order to improve their tribological properties (M. Assoul, V. Malkhasyan, G. Monteil). In order to increase the durability of tools, a team of researchers specialized in manufacturing and tribology (M. Assoul, M. Fontaine, A. Gilbin, H. Meliani, G. Monteil,) then had the idea of texturing cutting tools to improve their wear resistance and their ability to machine small geometries without deforming them by limiting the cutting forces. This work was financially supported by the Franche-Comté region and by two regional bar turners, DDLG in Ornans and Baron Décolletage in Grand'Combe Châteleu. Within the framework of this research, two types of textures are applied by means of a femtosecond laser (Figure 1). Textures of microscopic size, in the form of lines parallel to the cutting edge or holes with regular spacing, are made on the surface of the cutting inserts. Nano-sized textures, in the form of sub-micrometre wide ripples, can also be generated directly by the interaction between the laser and the tool materials, typically tungsten carbide and titanium-based coatings (Figure 2).

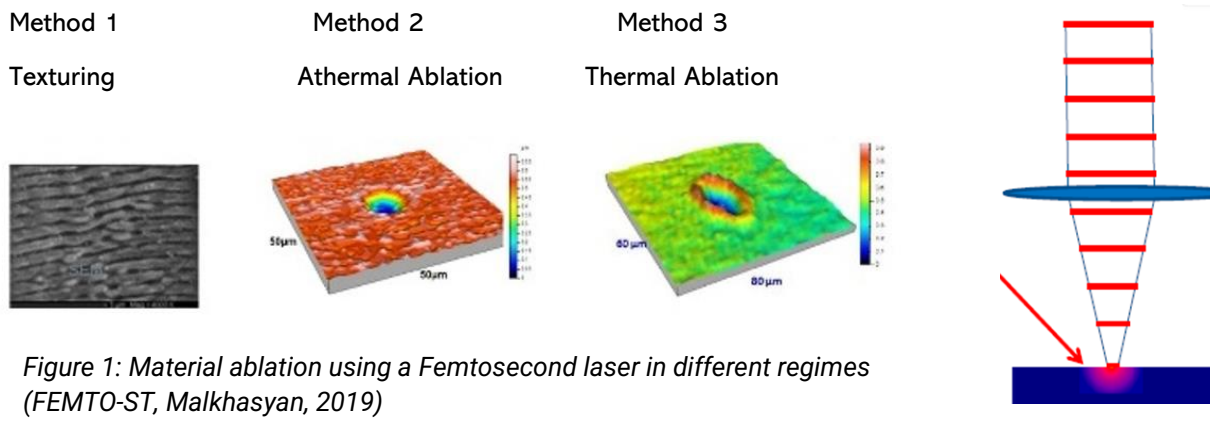


Figure 1: Material ablation using a Femtosecond laser in different regimes (FEMTO-ST, Malkhasyan, 2019)

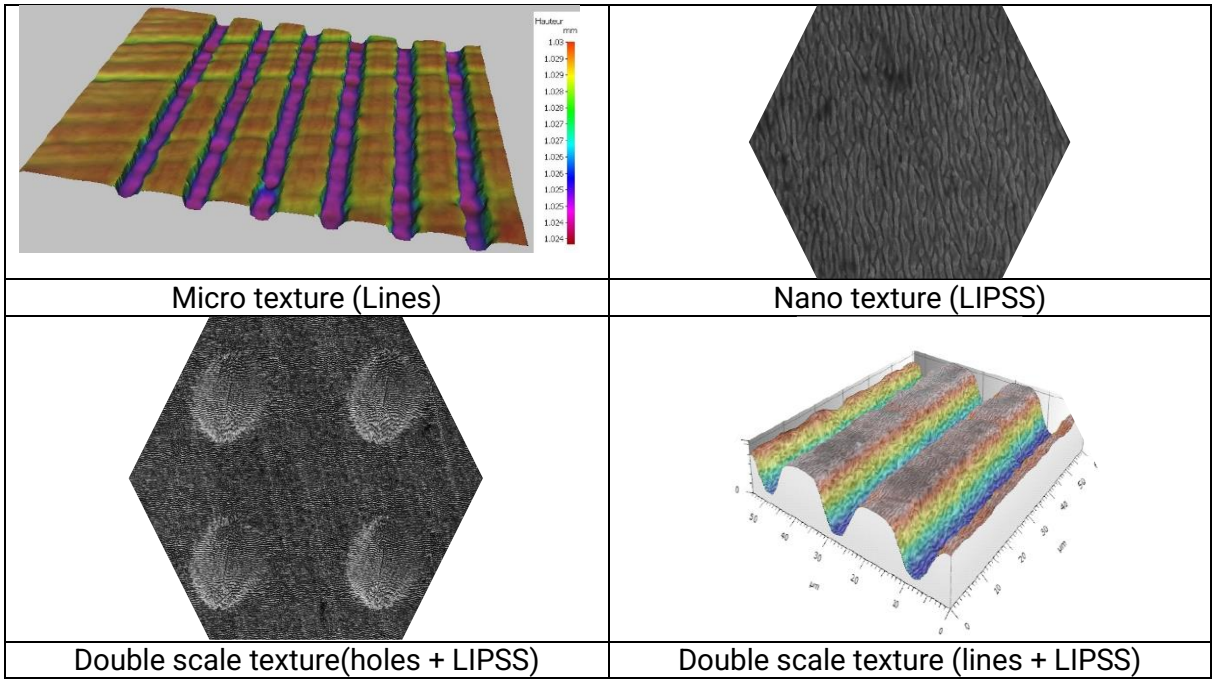


Figure 2: Topographic 3D view and SEM images of the produced textures (FEMTO-ST, Meliani, 2020)

These textures, micro, nano or double scale, are then very simply characterized by means of a high-resolution 3D optical system InfiniteFocus Bruker Alicona belonging to the laboratory, as well as the software MeX Bruker Alicona of 3D reconstruction of stereoscopic images obtained on a SEM at FEMTO-ST.

Figure 3: InfiniteFocus AdvancedReal3D Bruker Alicona

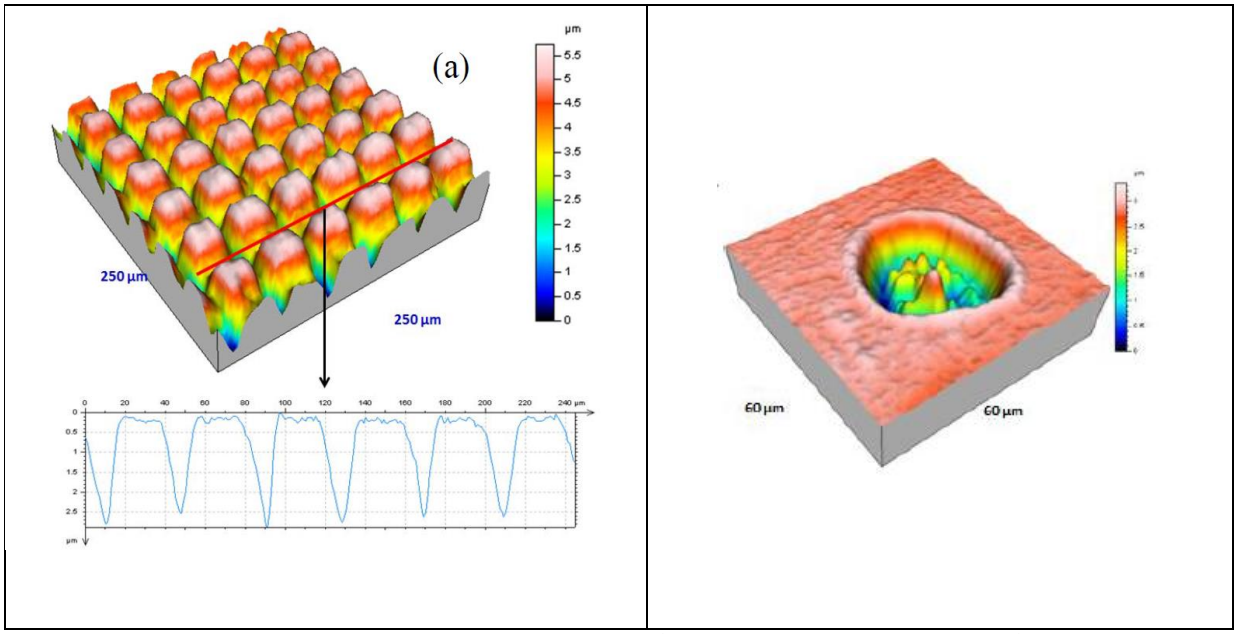
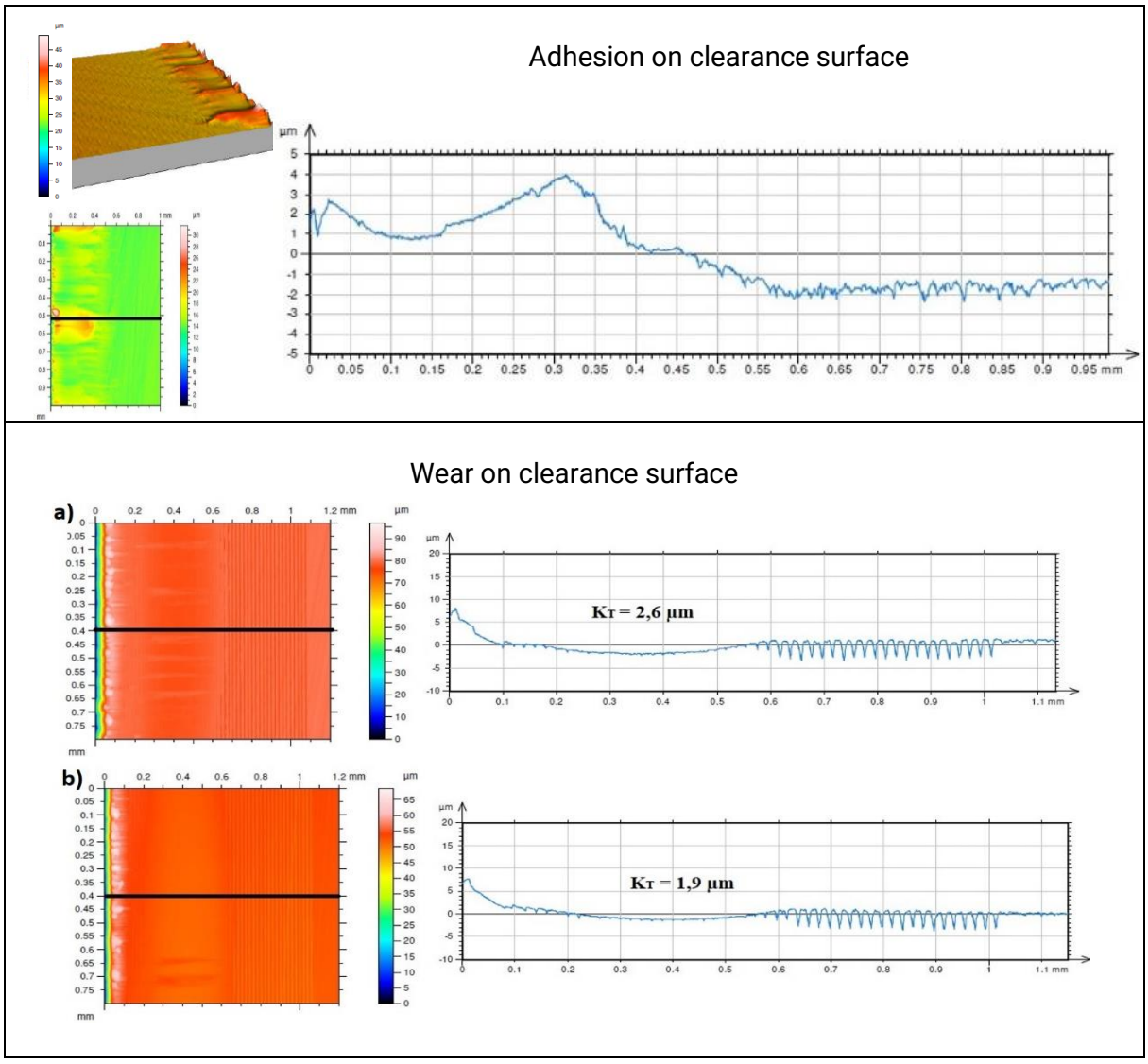


Figure 4: Topographic acquisition of laser microtextures (FEMTO-ST, Monteil et al., 2013)

Characterization of Wear

Once the machining tests have been carried out at the ENSMM and at the MIFHySTO mechanical micro-manufacturing platform, the InfiniteFocus metrology system is used to characterize adhesion and abrasion resulting from the machining operation. The measured wear is a crater wear on the cutting face, as well as a more classical abrasion wear on the clearance face (Figure 5). With the same means, the adhesion is also observed and measured. Indeed, the machined material sticks on the zones close to the cutting edge and forms a bead before the zone presenting abrasion, located between the bead and the textured zone.



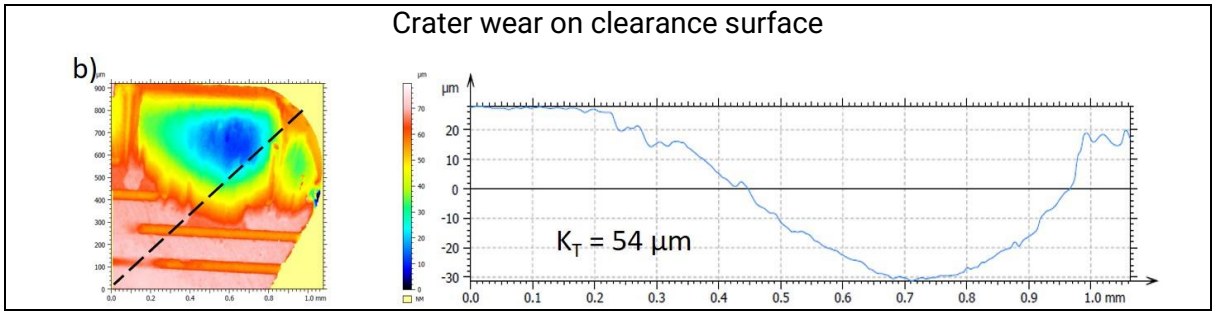


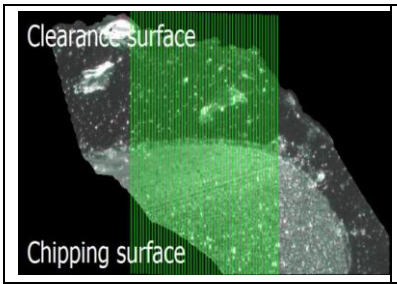
Figure 5: Acquisition and measurement of different types of wear on microtextured cutting tools (FEMTO-ST, Meliani, 2020)

The interest of the measurement tool is to be able to characterize quickly and with a high resolution, surfaces larger than a single measurement field, by assembling several individual data sets on uneven surfaces, without tiling effect on the connection zones. This allows the researchers to carry out acquisitions on important surfaces on the studied cutting tools, in order to be able to compare in a second time the acquired data with numerical simulations carried out in order to analyze phenomena occurring during the cutting process, like the tool-chip contact length for example.

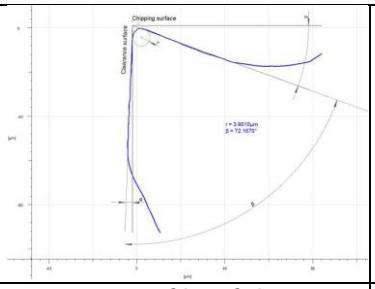
The objective of this research is also to determine if this type of texturing can be brought to replace certain coatings in the case of cutting tools used for micro machining operations. Indeed, coatings have a significant impact on the radius of cutting edges and this parameter is particularly influential on the efficiency of micro tools. Micro-tool sharpening aims to create very small cutting-edge radii in order to obtain a fine and precise cut, but the tool must remain strong enough to limit its wear during the machining phase. One way to improve the wear resistance of the tool is usually to apply a titanium-based coating on the micro-tool, but this expends the cutting-edge radius. Micro and nano texturing are therefore aimed at improving the wear resistance of the tool, without penalizing the geometry of the cutting edge, which can be controlled on the same measuring device.

Measurement of cutting edges

The InfiniteFocus allows the scanning of surfaces with large slopes, without artificially creating measurement artifacts in areas with slope variations, while maintaining high lateral and vertical resolution. The cutting-edge measurement software then provides a robust and completely operator-independent measurement of the radius and geometry of the cutting edge (Figure 6).



Profile expansion area



Average profile of the edge

Name	Value	[u]	Description
r	3.9510	µm	Mean radius of mean edge
α	-2.0642	°	Clearance angle
β	72.1670	°	Wedge angle
γ	19.8972	°	Chip angle
Sα	15.0908	µm	Dist. apex to end of clearance roundness (former: a)
Sγ	3.0240	µm	Dist. apex to end of chipping roundness (former: b)
K	0.2004		Symmetry of cutting edge
Δr	4.3083	µm	Min. dist. of edge to apex (former: S)
Ecq	0.0770	µm	Form deviation of circle (RMS)
Form	Waterfall		Estimated Curvature

Average edge parameters

Figure 6: Acquisition and analysis of a cutting edge (FEMTO-ST, 2017).

Conclusion

The 3D optical InfiniteFocus Bruker Alicona system is a versatile high resolution metrology equipment that allows the FEMTO-ST Institute to characterize in a robust and operator independent way the surfaces and geometries of micro and nano textured cutting tools, in the framework of research on micro-manufacturing processes. This is only one example of the multiple applications of the system within the research centre which also uses it intensively in the framework of research in µ-milling, µ-turning, µ-electro-erosion and tribology. This equipment is present on the AMETISTE platform and it is currently the most used shared experimental device of the Applied Mechanics Department of the FEMTO-ST Institute.

Our thanks to for the data used in this report

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(2) FEMTO-ST Institute, University of Bourgogne Franche-Comté, CNRS/ENSMM/UFC, Besançon, France

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