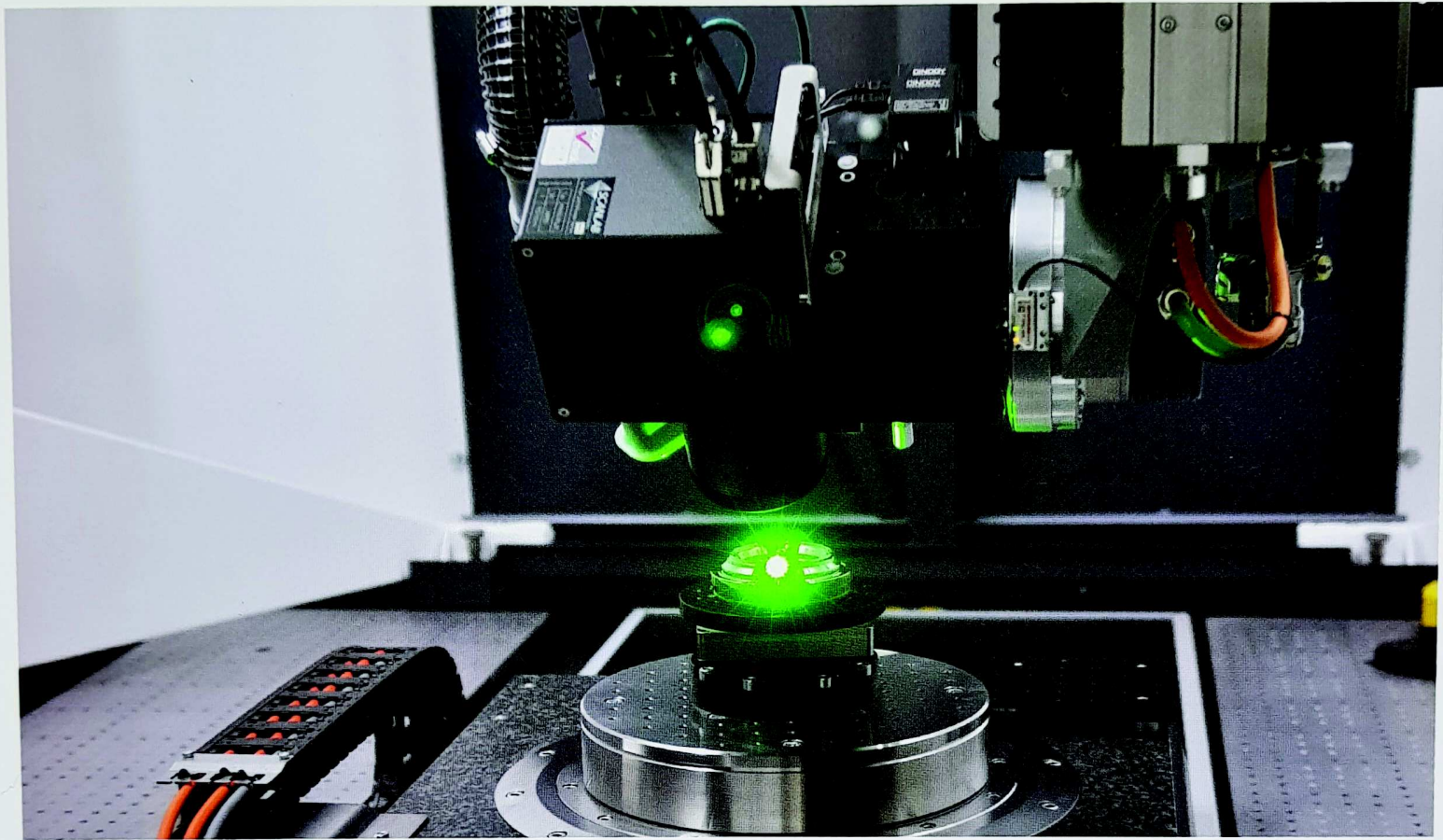


Fast and accurate micro-milling for high-definition surface textures



Introduction

The goal of the FAST project was to assess if/how recent scan system improvements could be used to improve the speed and/or quality of high-definition laser surface texturing processes. A fast gating mode and a faster / small aperture scan head were tested for an application where mold inserts needed to have a micro-pillar texture applied.

Scan system requirements for micro-milling / surface texturing

Achieving faster laser micro-milling processes means having to use a higher average laser power, which in turn will generally require one to **use high scan speeds to avoid heat accumulation**, which can have a negative effect on the surface quality or cause excessive melt, causing the definition of the texture to suffer.

Surface texturing on a double-curved surface means the processing of the target surface needs to be split into small tiles, which can result in a low duty cycle

when the scanner is spending a significant amount of time on jumps and run-ins. A **small aperture scan head** with smaller / lighter scan mirrors can be used to **reduce the time needed for run-ins / re-positioning**.

A high definition texture will often have many small features. A fast process for making such textures requires a complex gating pattern where the **laser needs to be rapidly and accurately toggled on and off**, especially for high scan speeds. Ideally, the scan system control hardware should support a **laser output modulation at the full speed that the laser hardware can handle (> 2 MHz)**.

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The FAST project is part of the new equipment assessment experiments in the APPOLO project. This project received funding from the EU FP7 programme under grant agreement no 609355. The FAST experiment is a collaboration between SKF, SCANLAB and Lightmotif.

Results

Fast pixel mode for SCANLAB RTC5

A faster pixel output mode for the SCANLAB RTC5 control board was integrated and tested using scan speeds of up to 6 m/s. This fast pixel mode allows scanning of straight lines while modulating / gating the laser at the full rate that the laser hardware is capable of (> 2 MHz). **A hatch pattern stroke with many small line segments can be scanned in a single pass at high speeds without loss of texture definition.**

Small aperture scan head with digital encoders

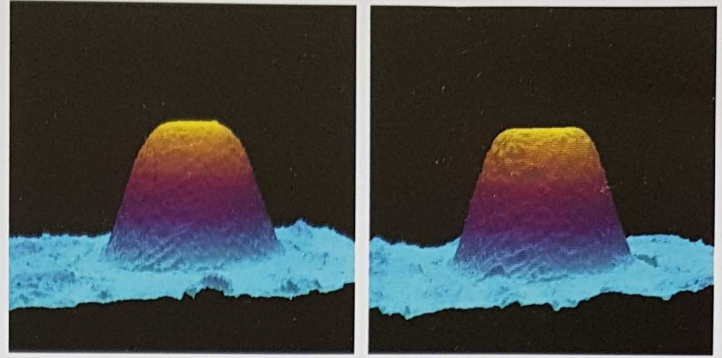
The intelliSCAN_{se} 10 is SCANLAB's smallest aperture scan head which features the digital encoder technology required for highly accurate laser micromachining. Compared to the intelliSCAN_{de} 14 mm the tracking error / time lag is almost twice as small. Both scanners were tested and the results confirm that **for the same high accuracy the time spent on re-positioning (jumps) and accelerating (run-ins) can be halved when using the smaller aperture.**

Mold inserts

Mold inserts for a bearing seal mold were textured using the improved scan system. The process used a relatively high scan speed (2 m/s) to avoid heat accumulation. Thanks to the fast and accurate gating the texture's small features still have a high definition. The fast dynamics of the small 10 mm aperture scan head enable a relatively high duty cycle when processing small tiles (70–90 %).

Demonstrators

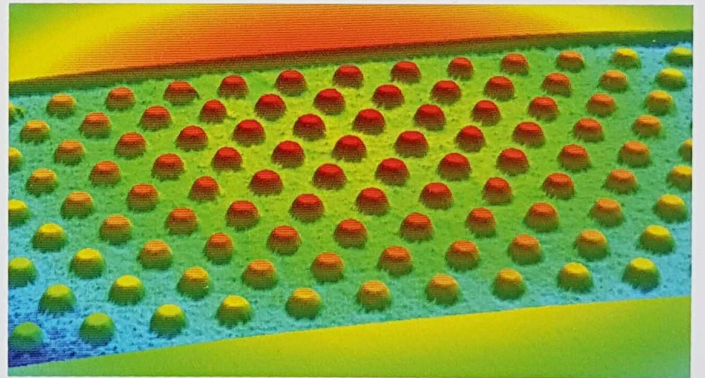
The technology was used to machine different pillar patterns in rings on balls made of stainless steel and cemented carbide. The picture to the right shows a measurement of the texture on a steel demonstrator ball.



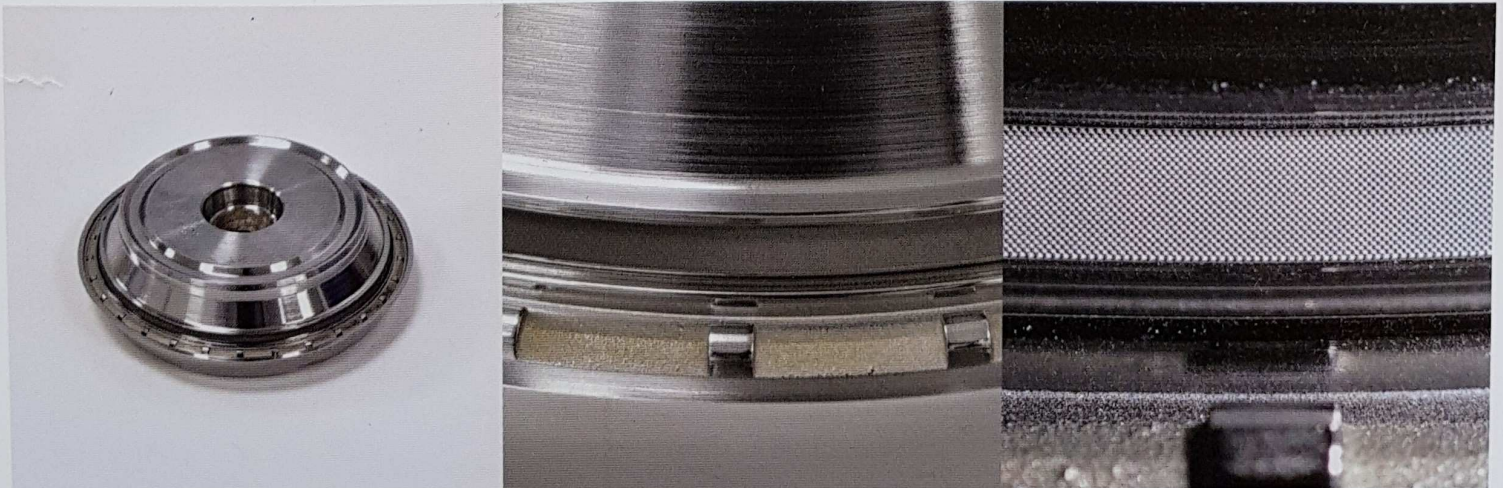
Two images of ~40 μm diameter pillars made with the exact same process (2 m/s scan speed), executed with a standard / 308 kHz pixel clock (left) and using the fast pixel mode (right).



Different pillar patterns are applied in rings to this demonstrator.



3D measurement of a pillar texture on one of the demonstrator balls.



Photographs of the textured mold insert, where a pillar texture was applied to a conical ring around the circumference.