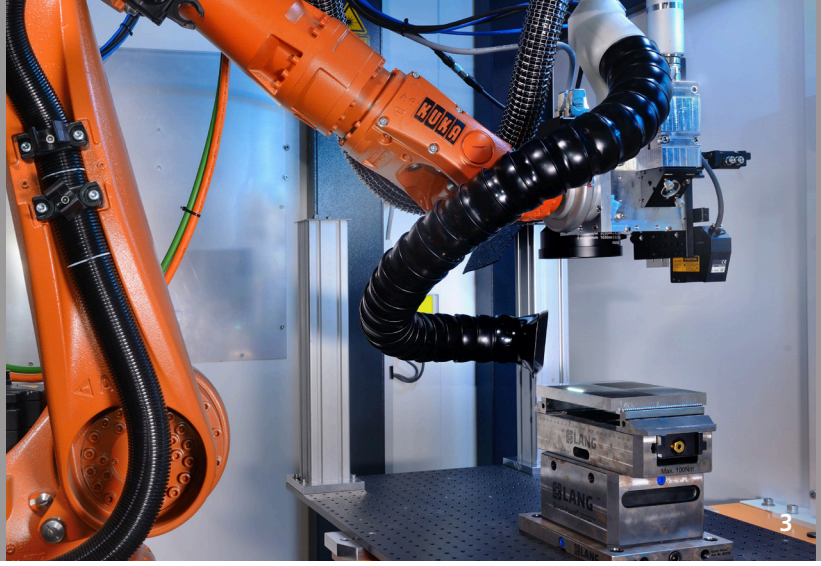

ROBOT-BASED USP STRUCTURING ON FREEFORM SURFACES

Task

Functional laser-based surface structuring is currently usually performed using high-precision 5-axis CNC machines and mirror-guided laser radiation, although 6-axis robots are a cost-effective alternative whenever a wide range of products need to be processed flexibly. However, since the commercial robots have low absolute accuracy, a sensor-based compensation strategy is required for microstructuring with accuracy requirements < 10 µm. Another challenge is posed by the fiber guidance of the ultrashort pulsed laser radiation used for precision processing in the robot system.

Method

When large 3D components are structured, the surface is mathematically divided into 2D patches, which are removed layer by layer. To produce a texture without visible patch boundaries, the patches in each layer must be positioned with < 10 µm repeat accuracy. To compensate for the insufficient robot accuracy, Fraunhofer ILT developed a sensor system for position measurement and correction. For this purpose, the system was equipped with a global measurement system and a local coaxial camera integrated into the laser beam path. Optical flow algorithms are used to calculate a displacement vector between the target and actual positions from the camera images and to compensate for this by correcting the robot position and scan vectors. Furthermore, the institute uses a real-time capable EtherCat PLC to synchronize the robot, the laser scanner and the sensors temporally.

Results

Fraunhofer ILT has developed modular software for overall machine control and communication between the individual systems. This software can be used to reorient the robot and recalculate the scan vectors to compensate for position deviations. With the camera and illumination system, specified displacements in the recorded image data could be reproducibly measured with a repeatability of < 1 µm in a test setup.

Applications

3D surface structuring is used in toolmaking, e.g. to produce design structures or microstructures for surface functionalization. In the automotive sector, the process can be utilized to apply optical and haptic design structures to the fittings in the vehicle interior.

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3 Industrial robot with laser scanner and coaxially integrated sensors (camera and external illumination 808 nm).

4 Structured surface textures.