DIPLAT

4th NEWSLETTER July 2015

WELCOME TO THE FOURTH DIPLAT NEWSLETTER – WITH A FOCUS ON SYNCHRONISATION AND DIPLAT PARTNER: EWAG

DIPLAT is a 42 month research project funded by the European Commission under the FP7 Programme to investigate and demonstrate: "Enabling advanced functionalities of Diamond and other ultra-hard materials by Integrated Pulsed Laser Ablation Technologies"

EWAG AG– creating tool performance

EWAG AG is a Swiss company manufacturing grinding and laser machines for tool production. Within the DIPLAT consortium EWAG AG is responsible for machine control systems and the industrialization of new laser ablation processes and strategies.

About EWAG

EWAG AG was founded 1946 as a manufacturer of precision tools for the Swiss watch industry. Due to the need for high precision grinding machine, EWAG started years later to develop own machines and the focus of the company changed from tool producer to machine tool manufacturer for high precision tool manufacturing.In the 1980's EWAG started to develop machine tool solutions for the diamond tool business and pioneered with the first combination of EDM (roughing) and grinding process (finishing) in one setup. This combined machining process was transferred in the 1990's to the new product series EWAMATIC LINE, a versatile highend 6-axis EDM-/grinding center.

Besides pressure-controlled diamond grinding and EDM-machining, EWAG started in 2008 with laser machining of superhard materials. EWAG focussed from beginning on the advantages of the ultrashort pulsed laser ablation with picosecond lasers and is respected in the market as the pionier for machining diamond tool edges and cavities with ultrashort pulsed lasers. The developed LASER LINE series provides a PLA workstation with a fully 5-axis kinematics, superposed galvo-scanhead and automatic focal spot shifter.

Today, EWAG stands for high precision and high quality machine tool solutions and is the world leading supplier, especially in the area of superhard material processing using grinding and laser technologies. EWAG has been a Körber Solutions and furthermore a UNITED GRINDING member since the year 2000. Since 2010 WALTER Maschinenbau GmbH and EWAG AG form together the WALTER EWAG tooling divison.

EWAG LASER LINE ULTRA – All in one manufacturing solution

Inside the LaserLine

From grinding to lasering

The demand for diamond tools for machining materials, such as CFRP or aluminum alloys, is on the rise. The trend toward even harder cutting materials such as CVD diamonds is taking today's grinding and electrical discharge machining technologies to their limits. However, the LASER LINE ULTRA enables these limits to be exceeded. A noticeable difference to conventional grinding and electrical discharge processes is the fact that laser processing is done without applying force and without cooling lubricants. The use of modern ultra-fast lasers allows a direct evaporation process without significant thermal input. This material removal process is called cold ablation. The material properties of the cutting materials are thus retained, there is no heat affected zone and the ultra-short pulses in combination with the high repetition rates lead to best surface qualities.

EWAG and DIPLAT

EWAG AG has two main tasks in the frame of the DIPLAT project. In the second half of the project EWAG is responsible for the industrialization in production aspects of the specified new tool geometries. For that an EWAG LASER LINE machine has been placed at the ETH in Zurich equipped with full automatization capabilities, which is based on a six axis robot capable of loading the tools within first series of tools in a highly efficient manner. The other main task concerns the production of tools with respect to highest precision at reasonable production times. Therefore a highly capable synchronization system of all in the process involved axes, beam scanning galvanometers and laser system triggering signals is required. The following text exploits this matter further in detail.

CNC, galvo-scanhead and laser synchronization

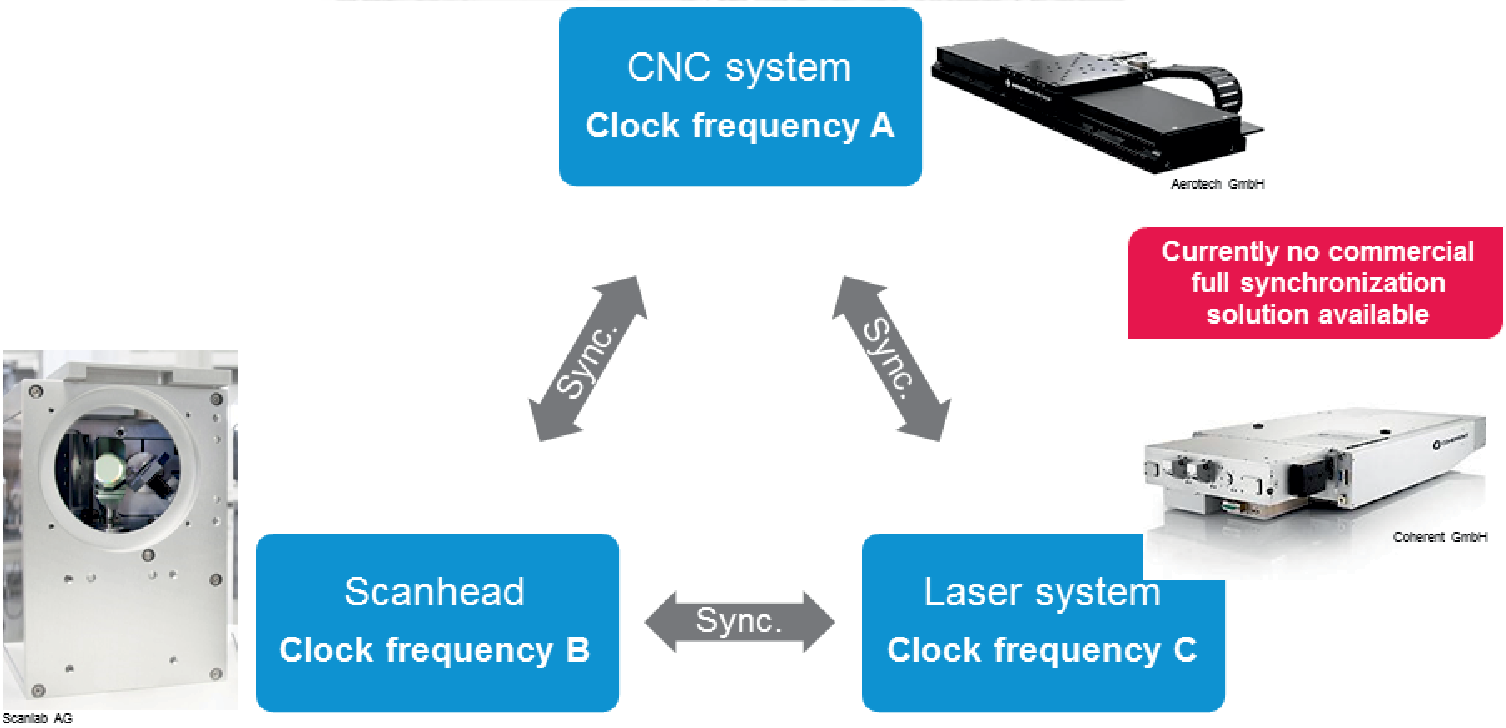
Laser for tools

In order to generate cutting tool geometries today a 4-5 axes (X,Y, Z, B, C) CNC-system is necessary due to the three-dimensional geometry of flank- and rake-face geometries. Laser systems in the short and ultrashort pulsewidth regime (ns - ps) and high repetition rates (some MHz) are industrially available and used today. Typically the applied CNC-system control operates in cycle time regimes of 1-2 ms by providing feed rates in the order of 1-10 m/min. By using such a system the pulse to pulse overlap between two consecutive laser pulses is close to 100%, inducing heat accumulation which can eventualy lead to a thermal removal of the material so that precise ablation cannot be reached. Therefore an additional laser beam deflection system (scanhead) is typically used. This fast deflection device has 2 to 3 galvanometer driven axes (parallel to the X,Y and Z mechanical axes) which enables feed rates of 1 to 10 m/s. A galvanometer is a rotary axis which can only swivel about the axis center. This enables control of pulse to pulse overlaps and provides control of the ablation volume geometry and highest surface quality characteristics. Typical cycle times on these systems are 10 µs steps for axes motion and 1 µs resolution for laser emission triggering.

Scanhead (SCANLAB)

Precision and speed

Typically, cutting tool geometries today are produced by using a pseudo-synchronization of the involved components. This is necessary because there is no system on the market which offers a full integration of galvanometer driven units together with NC axes when combining linear and rotary CNC-axes together with two galvanometer units. Therefore two different control protocols are used (CNC and scanhead) which do not exchange NC data while processing the given contour. Additionaly no pulse triggering is applied. The stated synchronization aspects are visualized in following figure.

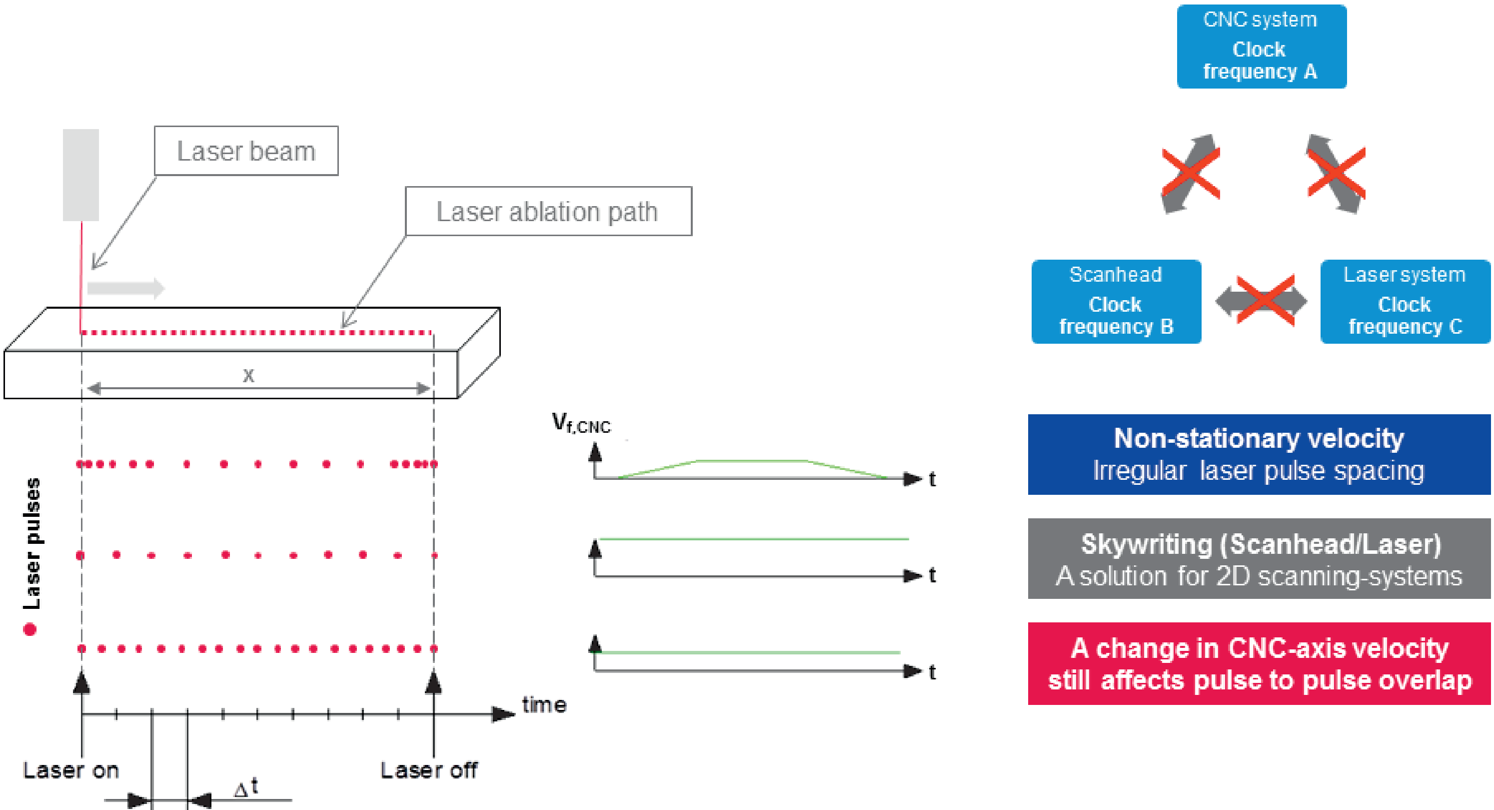


Typical control system situation. The CNC-system, the galvanometer based axes and the laser system operate on individual clock frequencies

Machining dynamics

High-speed or high precision

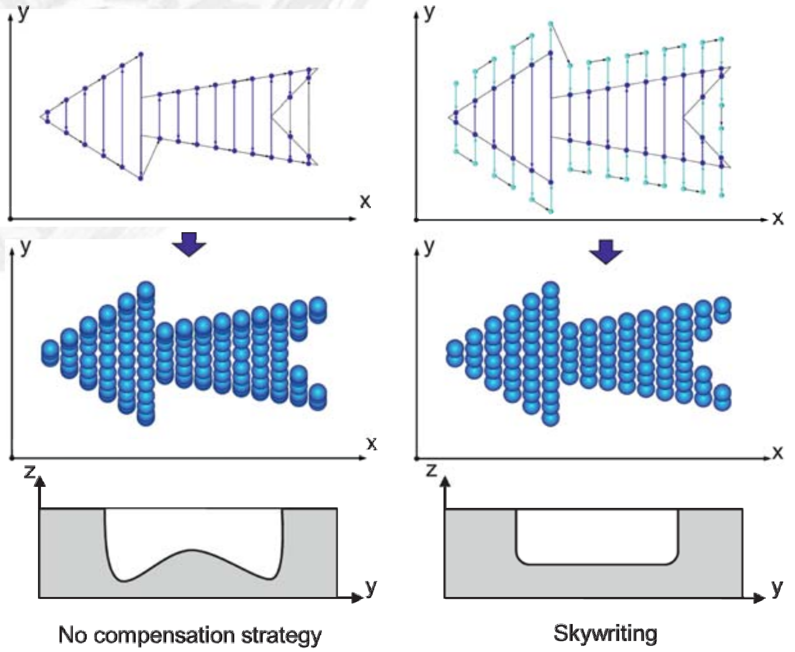
Due to large masses on the CNC-system (weight of the motors and the fixtures of the CNC-system) there is the chance of overswing motion (in case of a B/C-axes rotation) when executing high speed turns, which are necessary when executing small contour radii. In the given quasi synchronous motion the laser operates at a given pulse repetition rate and is not triggered on or off. Also the CNC-system is not able to provide a constant effective speed on the contour at high speeds throughout sharp turns. This leads to burn in marks on the lasered contour due to the constant laser irradiation and inconsistent velocity of the CNC-system.



Laser spot patterns (left) and velocity patterns (middle) for three variations. The topmost profile shows the marked laser spots if beam velocity varies while ablation. The middle image shows a feature called “Skywriting” leading to a shift of the acceleration and deceleration patterns outside of the scanning area. Even this feature cannot prevent non-homogeneous ablation if the scanhead motion is not synchronized to the CNC-axes motion.

Skywriting

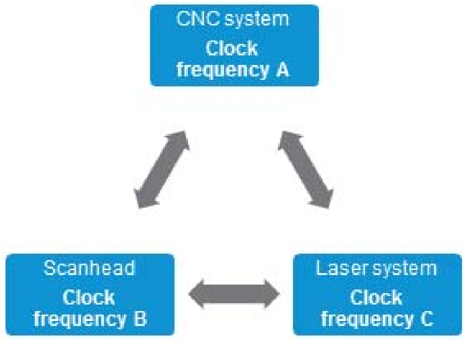
If a scanning system operates without compensation strategies, galvanometer acceleration and deceleration can be seen directly within the ablation pattern by a smaller pulse to pulse spacing at the beginning or the end of the marking groove. A software alternative to eliminate this fact is given by using a solution called “Skywriting”. This enables the scanhead to place the acceleration and deceleration paths outside the actual contour to be lasered, therefore eliminates the burn in marks. Even if this is active the problem of non-synchronous motion between the scanhead system and the CNC-system remains, leading to inhomogeneous ablation patterns if the CNC velocity profile changes throughout the ablation procedure.

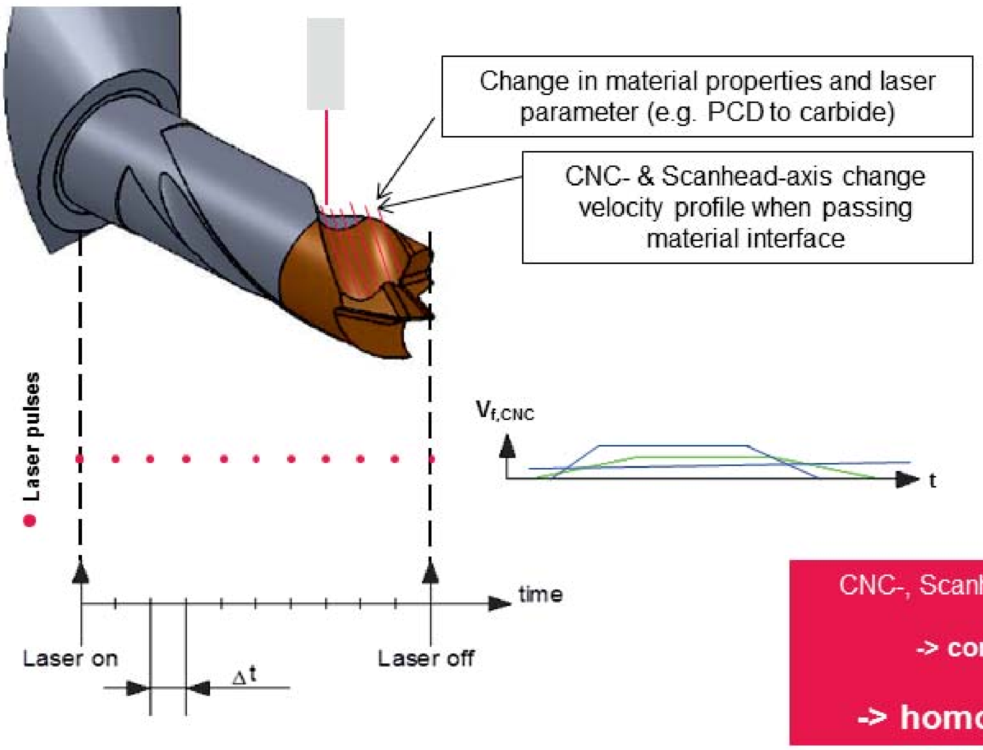


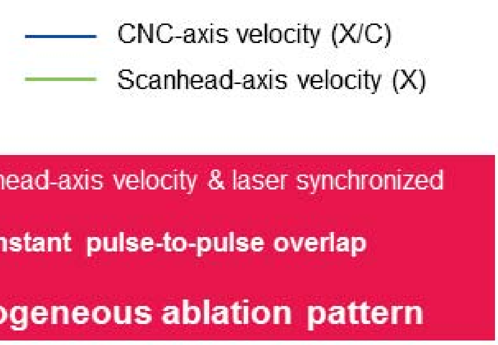
Scanning path (top), laser pulses distribution (center) and ablation profile (bottom)

Synchronization

The CNC- and scanhead-axes need to be controlled via one single NC dataset by only one controller and the laser triggering will also be controlled by that system.







A solution to the non-homogenous ablation regime is to synchronize all necessary control signals by using one single cycle frequency

In order to overcome the physical problems of overswing motion patterns due to high speed motion in tight radii situations the following approach will be designed and tested. Instead of working on the CNC-system parameters to improve motion characteristics a constant pulse to pulse overlap on the entire contour is enabled by controlling the laser pulse release pattern with respect to the current track speed while machining the contour. This enables a constant pulse to pulse overlap even if the CNC-axes motion pattern is not stationary in speed. This is expected to provide excellent results due to identical ablation characteristics on all locations throughout the contour.

Laser processing of a PCD tool on the Laserline

Current status within DIPLAT

Currently various tool geometries are tested and manufactured. The synchronization aspects are further exploited and implemented, followed by testing of the individual components and patterns. Synchronization is expected to lead to higher contour tolerance capabilities of the entire processing system leading towards a new era in manufacturing of precision tools.

ETH zürich · The University of Nottingham (United Kingdom · China · Malaysia) · diamoutils · element six · REISHAUER Gear Grinding Technology · Struers · WALTER · EWAG · ZEEKO

DIPLAT website: http://www.fp7-diplat.eu

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SEVENTH FRAMEWORK PROGRAMME