Femtosecond Laser Ablation for High-Speed Elemental Mapping at 2kHz

George Cooper[1], David Douglas[2], Edward Inglis[1], Marc-Alban Millet[1], Joshua Stone[2] and Leif Summerfield[2]
[1]School of Earth and Cardiff; [2]Elemental Scientific Lasers, Huntingdon, United Kingdom

Elemental Scientific LASERS
INNOVATION TO ILLUMINATE

Introduction

Recent advances in laser ablation (LA) hardware such as the TwoVol3 and DCI2, provide low particle dispersion (<1ms single pulse response), and when used in combination with high level LA-ICP software communication enables fast elemental mapping at >1MPx/s.

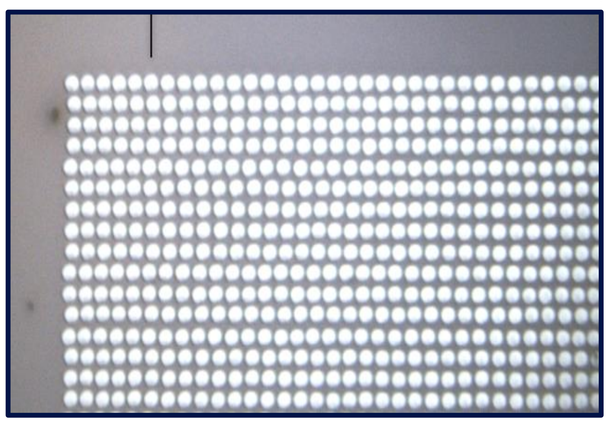
Combining this functionality with excimer or Nd:YAG lasers that can be externally triggered is straightforward. However, commercially available Yb:YAG femtosecond lasers are internally triggered, posing difficulties in ensuring accurate placement of the first shot in a line and alignment of subsequent sampling lines.

Using ffemtosecond systems for LA-ICPMS elemental mapping is advantageous: yields smaller particle size distribution, reduced thermal effects and reduced elemental/isotopic fractionation; all culminating in improved data precision. In addition to analytical figures of merit the solid-state 257 nm Yb:YAG laser can run at repetition rates of 2 kHz and beyond whilst also providing lower ongoing cost of ownership (no need to frequently exchange ArF gas and longer lasting optics due to the longer wavelength).

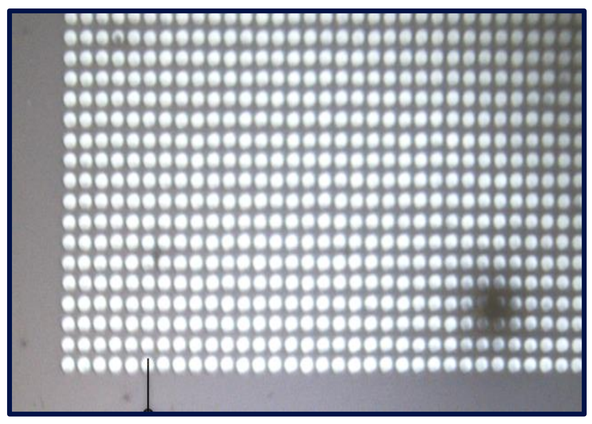
Here we demonstrate a novel combination of software architecture and system controller to align motion control and laser control to define specific triggering for absolute accuracy in shot placement when using a femtosecond laser at repetition rates up to 2 KHz and imaging at 2 mega pixels per hour

TwoVol3 Stage Accuracy and Shot Placement

In combination with the novel triggering of a femtosecond laser, the TwoVol3 stage closed loop feedback provides spot and pattern placement accuracy to within 100nm. This is critical to ensuring sequential spots and parallel imaging lines are reproducibly spaced to avoid artefacts in elemental map construction.



Poor trigger control: difficulties in aligning shot placement for an internally triggered laser



Correct triggering of the laser to synchronise with the high-precision motion control.

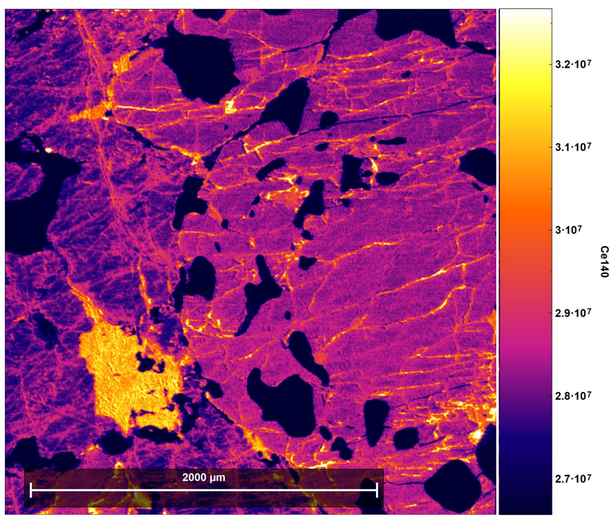
TVTuner – Automatic Washout Optimisation

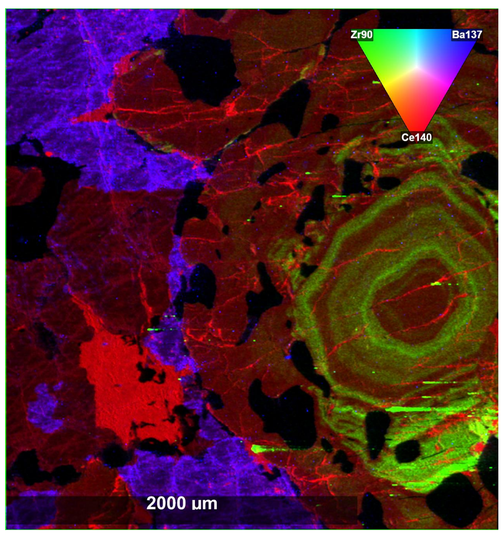
High-level communication between LA system and mass spectrometer provides bi-directional triggering, transfer of metadata and signal data. ESL's TVTuner automatically tunes gas flows and sample-extraction distances for optimum performance and washouts <1ms.

Elemental Maps Using the ESLFemto, TwoVol3 and DCI2.

A pegmatite sample was mapped using the ESLFemto coupled to a TOFWERK S2 via the DCI2.

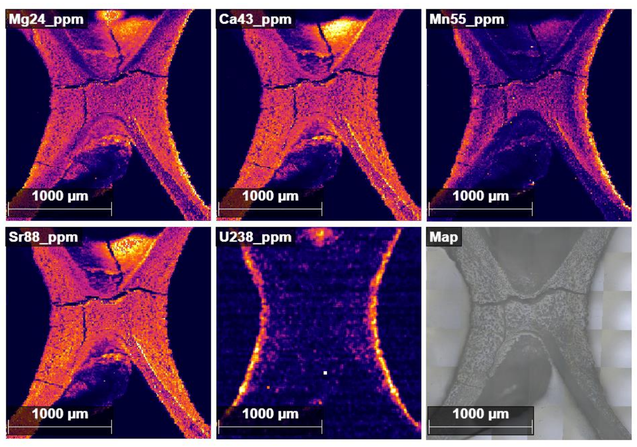
Map area	3003 x 3000 µm
Spot size	3 µm
Overlap	0 µm
Scan speed	6000 µm·s^{-1}
Repetition rate	2000 Hz
Total analysis time	33 min 42 s
Mapping speed	1.8 MPx/hour





A shark vertebrae sample was mapped using the ESLFemto coupled to an Agilent 8900 via the DCI2.

Map area	2000 x 2074 µm
Spot size	10 µm
Overlap	9.9 µm
Scan speed	48 µm·s^{-1}
Repetition rate	500 Hz



Elemental Scientific LASERS

iolite An Elemental Scientific Company

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD