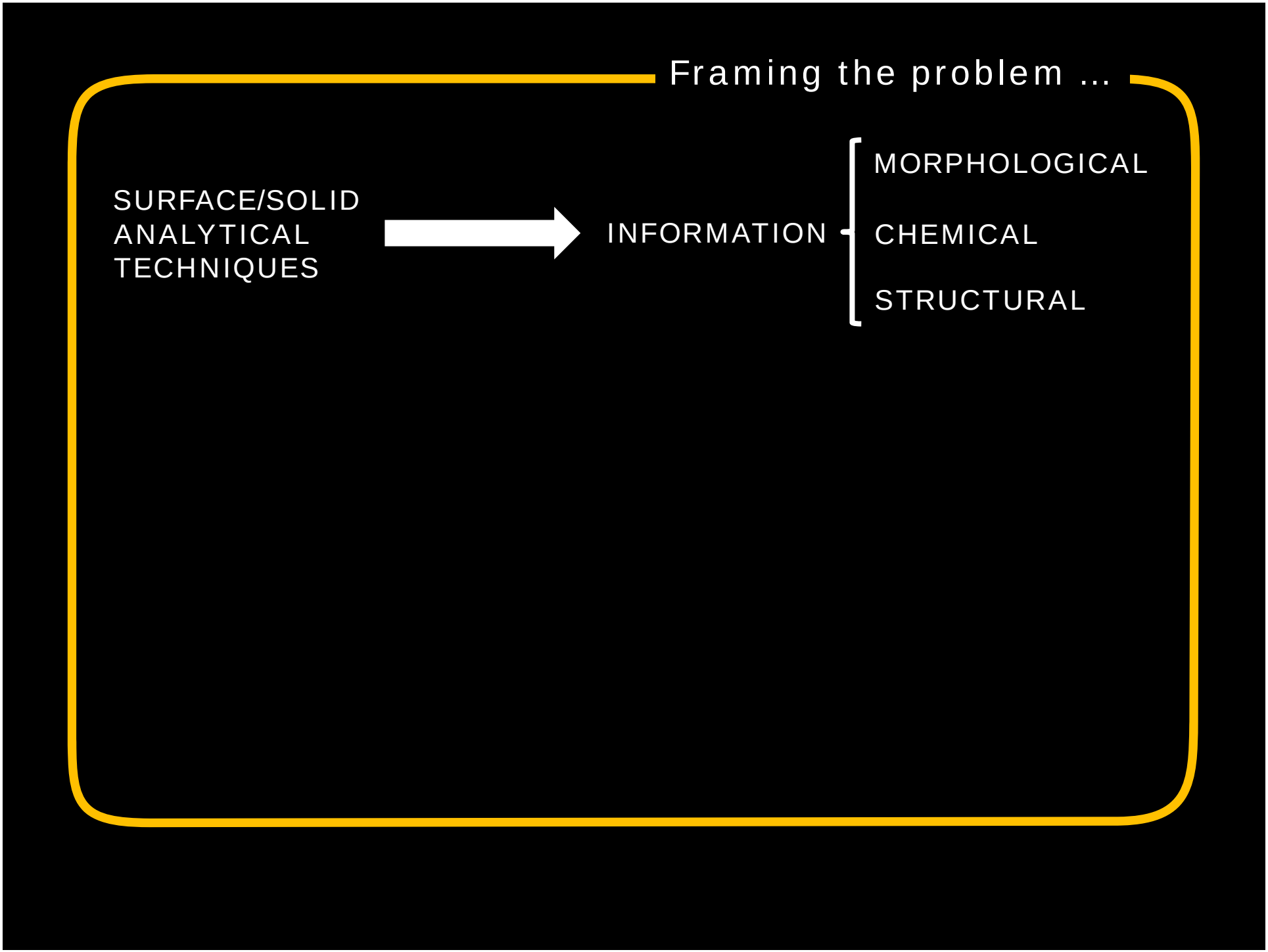
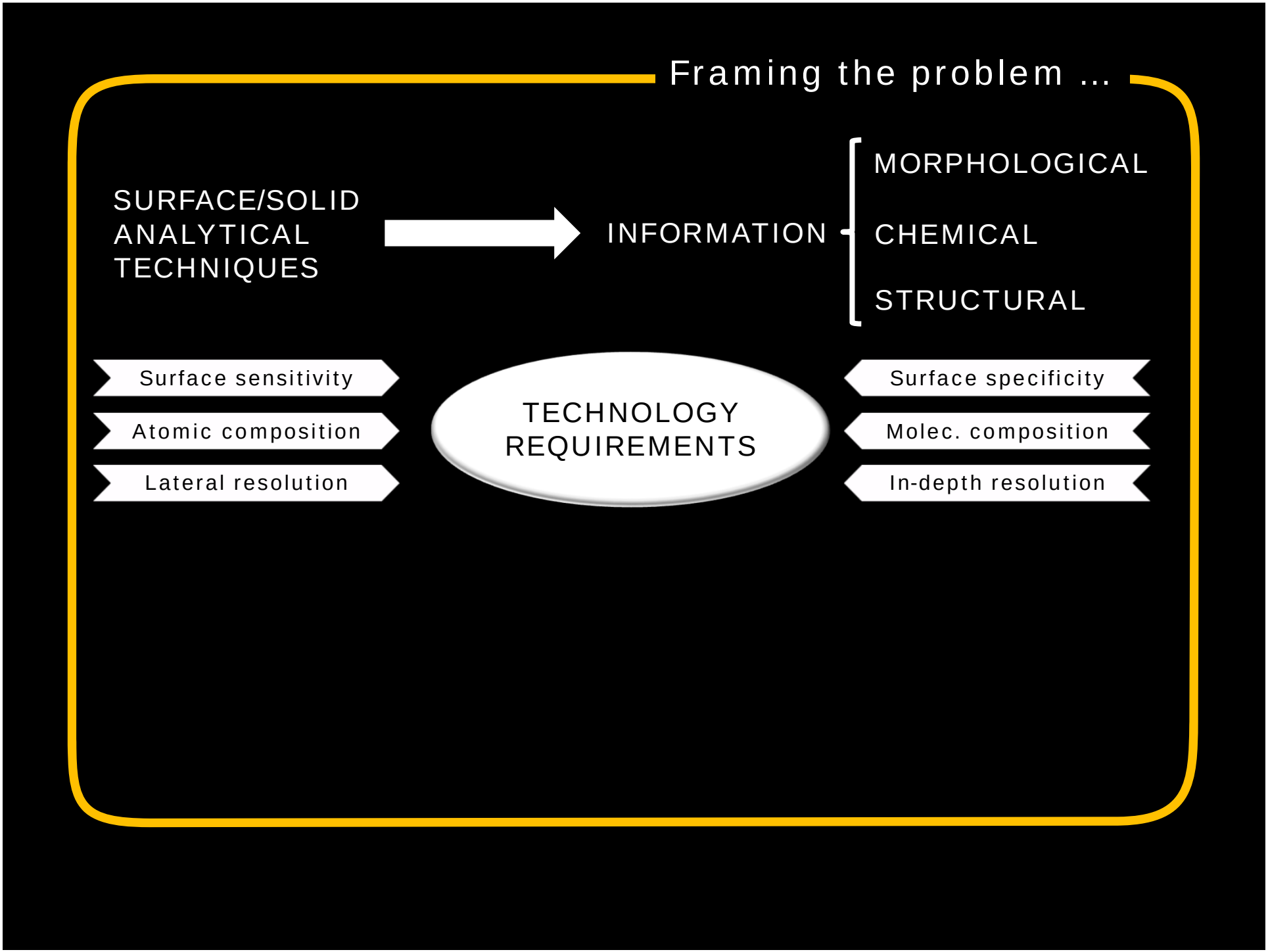
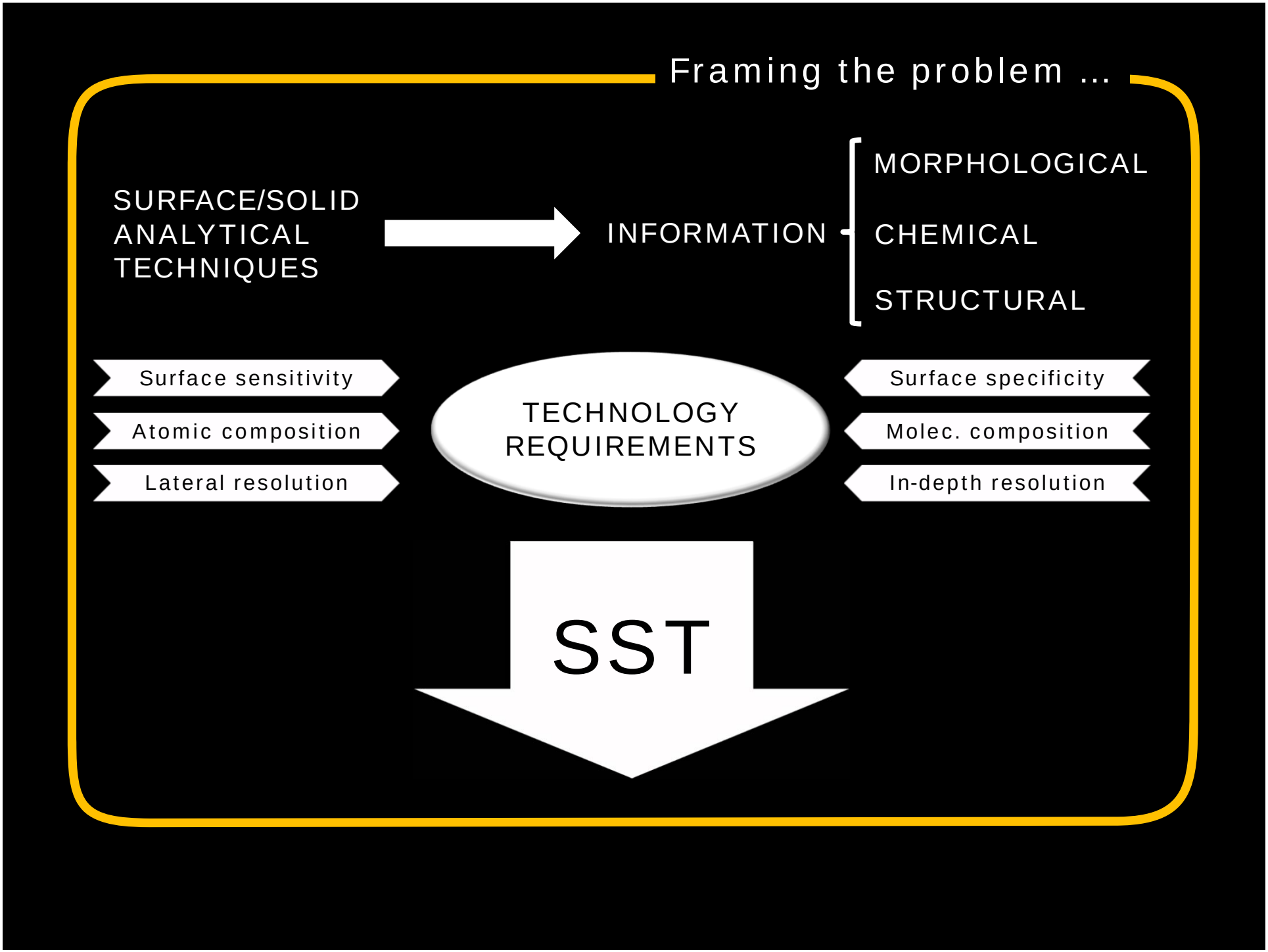
Single-shot laser-ionization mass spectrometry for direct atomic analysis

José_M_VADILLO // J_Javier_LASERNA

Universidad de Málaga, UMALASERLAB, Málaga, Spain
URL: laser.uma.es


Framing the problem ...
SURFACE/SOLID
ANALYTICAL
TECHNIQUES
INFORMATION
MORPHOLOGICAL
CHEMICAL
STRUCTURAL


Framing the problem ...
SURFACE/SOLID ANALYTICAL TECHNIQUES
INFORMATION
MORPHOLOGICAL
CHEMICAL
STRUCTURAL
Surface sensitivity
Atomic composition
Lateral resolution
TECHNOLOGY REQUIREMENTS
Surface specificity
Molec. composition
In-depth resolution


Framing the problem ...
SURFACE/SOLID ANALYTICAL TECHNIQUES
INFORMATION
MORPHOLOGICAL
CHEMICAL
STRUCTURAL
Surface sensitivity
Atomic composition
Lateral resolution
TECHNOLOGY REQUIREMENTS
Surface specificity
Molec. composition
In-depth resolution
SST

Points to consider ...

Direct laser ionization of solids (LIMS, laser-ionization mass spectrometry) is an amazing way to get full atomic information about sample microlocations.

Spatial resolutions as low a few microns are easily attainable with conventional optics, with sampling mass in the low femtogram per pulse range.

It has few limitations with respect to sample type (all of them shared with other vacuum-based techniques).

The only limitation of the technique relies on his moderate reproducibility and sensitivity.

Points to consider ...

Direct laser ionization of solids (LIMS, laser-ionization mass spectrometry) is an amazing way to get full atomic information about sample microlocations.

Spatial resolutions as low a few microns are easily attainable with conventional optics, with sampling mass in the low femtogram per pulse range.

It has few limitations with respect to sample type (all of them shared with other vacuum-based techniques).

The only limitation of the technique relies on his moderate reproducibility and sensitivity.

Points to consider ...

Direct laser ionization of solids (LIMS, laser-ionization mass spectrometry) is an amazing way to get full atomic information about sample microlocations.

Spatial resolutions as low a few microns are easily attainable with conventional optics, with sampling mass in the low femtogram per pulse range.

It has few limitations with respect to sample type (all of them shared with other vacuum-based techniques).

The only limitation of the technique relies on his moderate reproducibility and sensitivity.

Points to consider ...

Direct laser ionization of solids (LIMS, laser-ionization mass spectrometry) is an amazing way to get full atomic information about sample microlocations.

Spatial resolutions as low a few microns are easily attainable with conventional optics, with sampling mass in the low femtogram per pulse range.

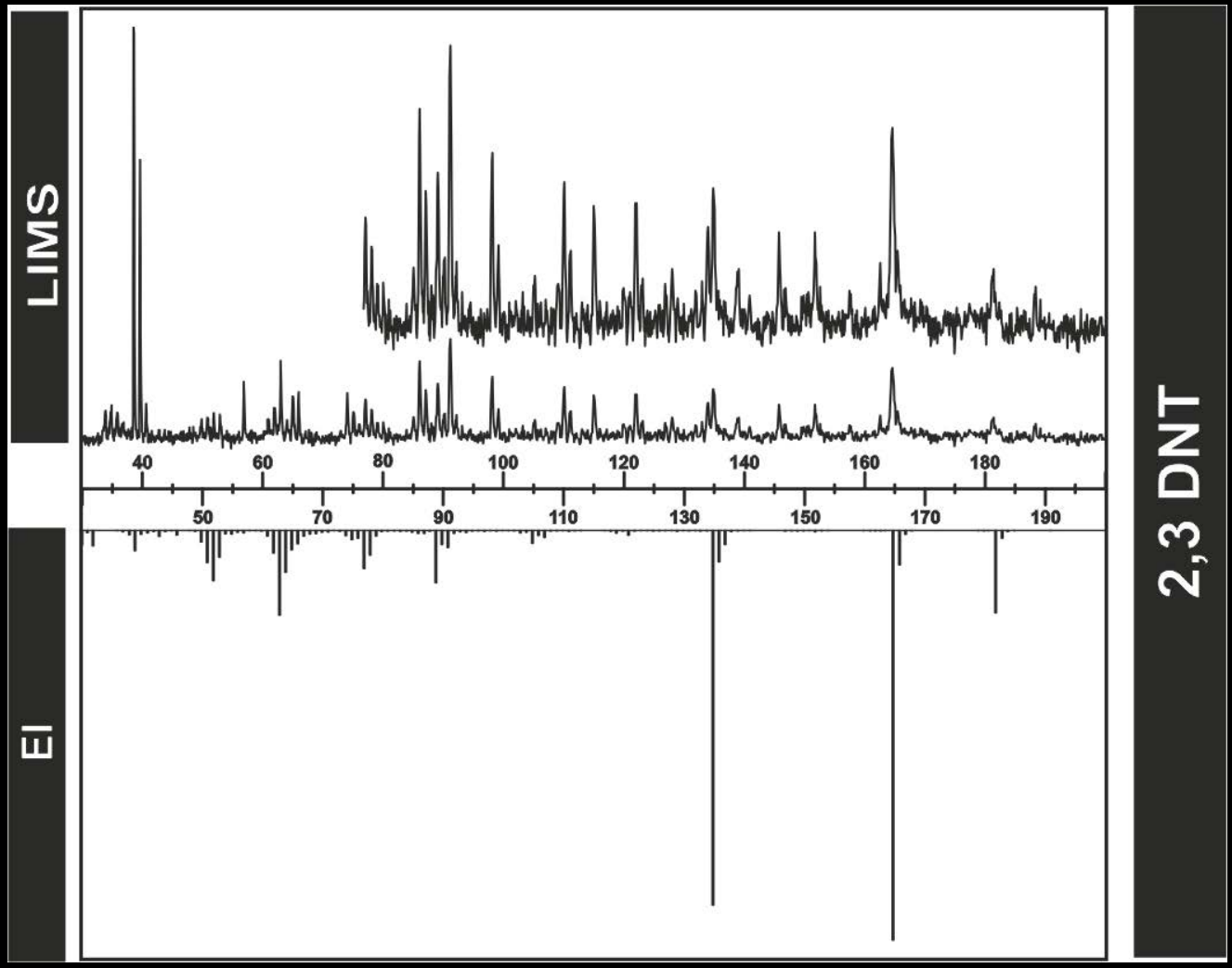
It has few with respect to sample type (all of them shared with other vacuum-based techniques).

The only limitation of the technique relies on his moderate reproducibility and sensitivity.

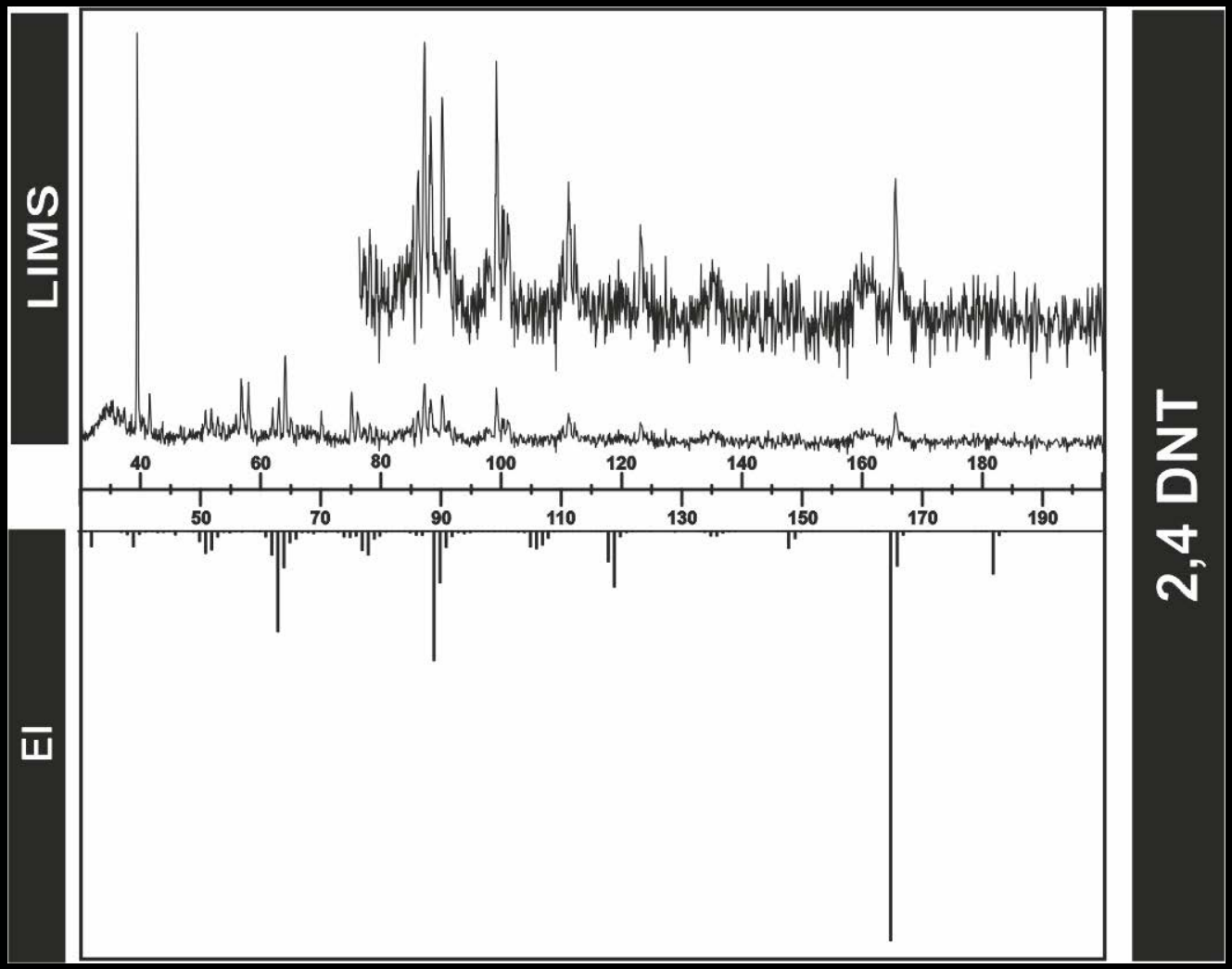
Points to consider ...

Everything turns much more difficult under SINGLE SHOT conditions

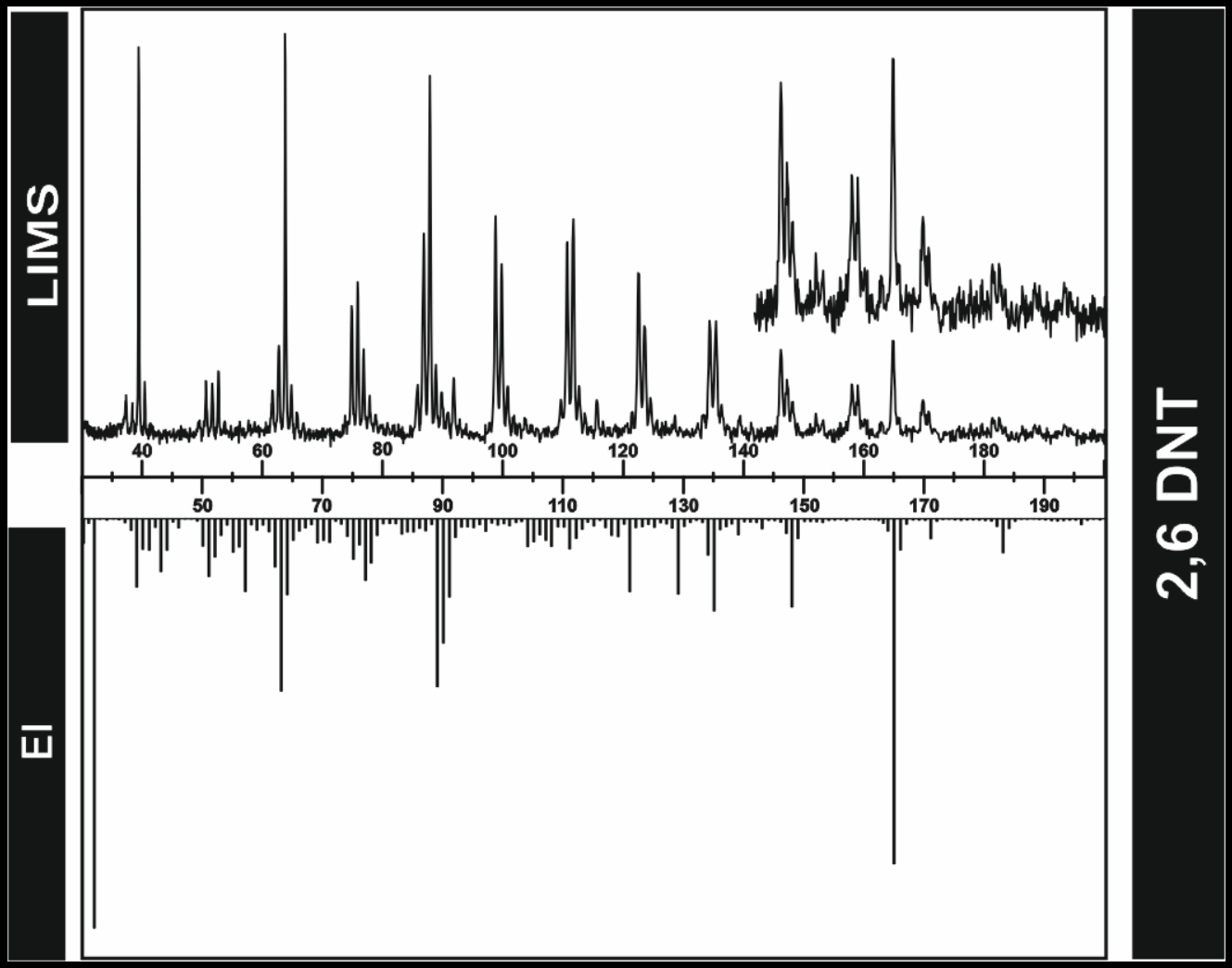
SS fingerprinting ...



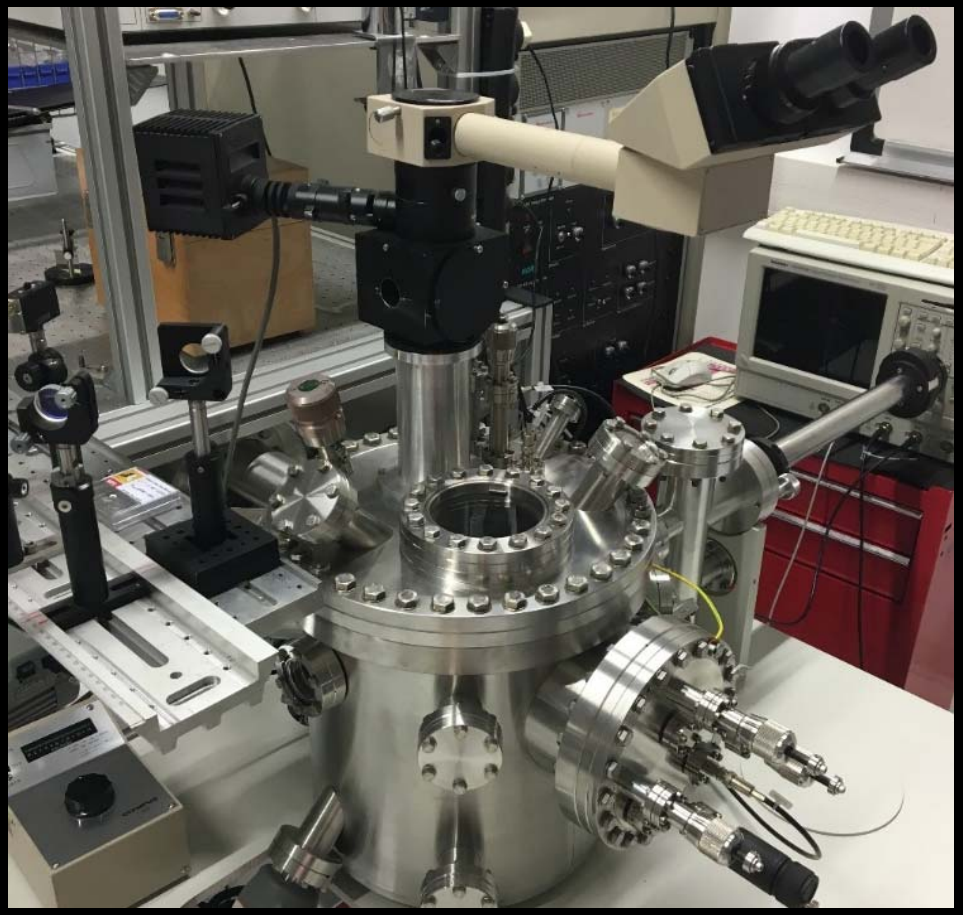
SS fingerprinting ...

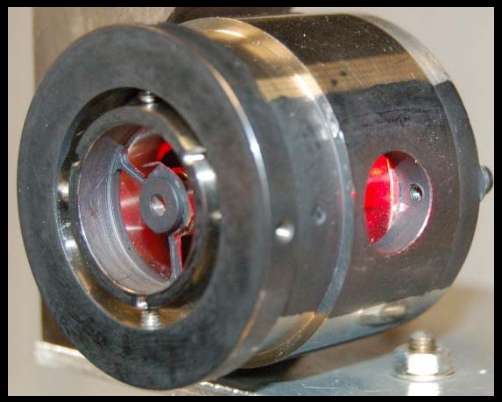


SS fingerprinting ...



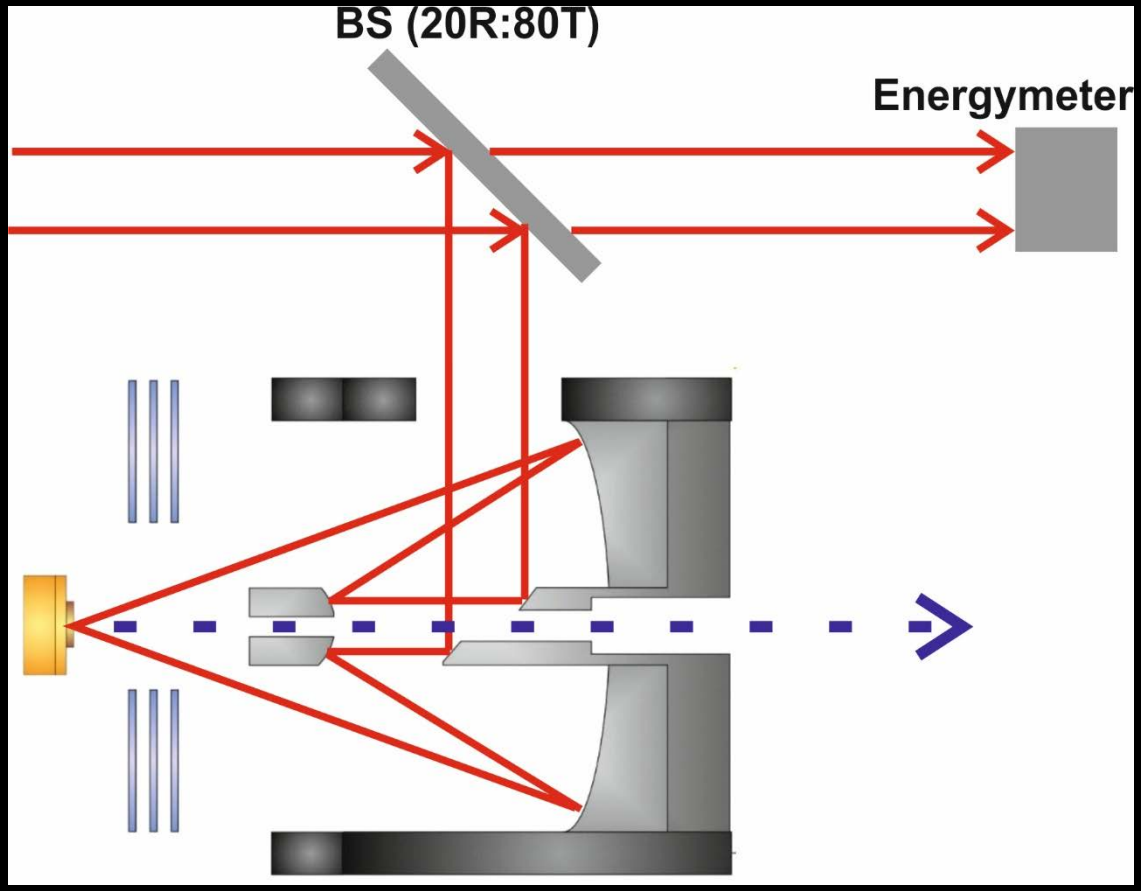
Weird things ...



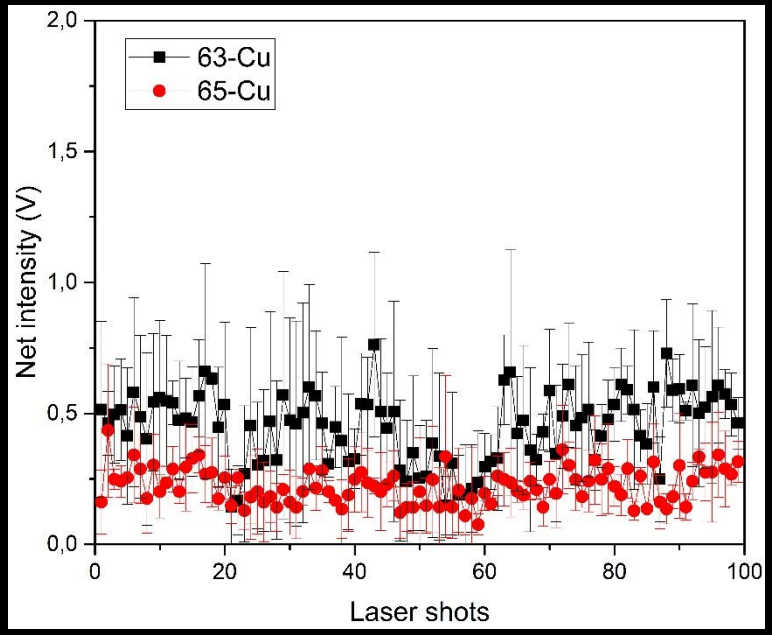


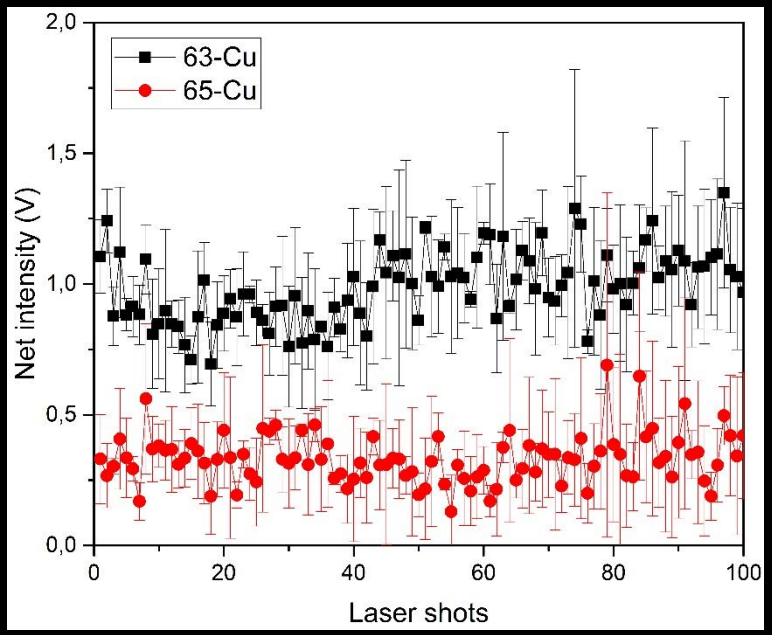
- Totally reflective metal system
- 180 nm – 5 μm
- Ion lenses
- Whole on-axis geometry
- Smaller craters
- High magnification (150x)

Weird things ...

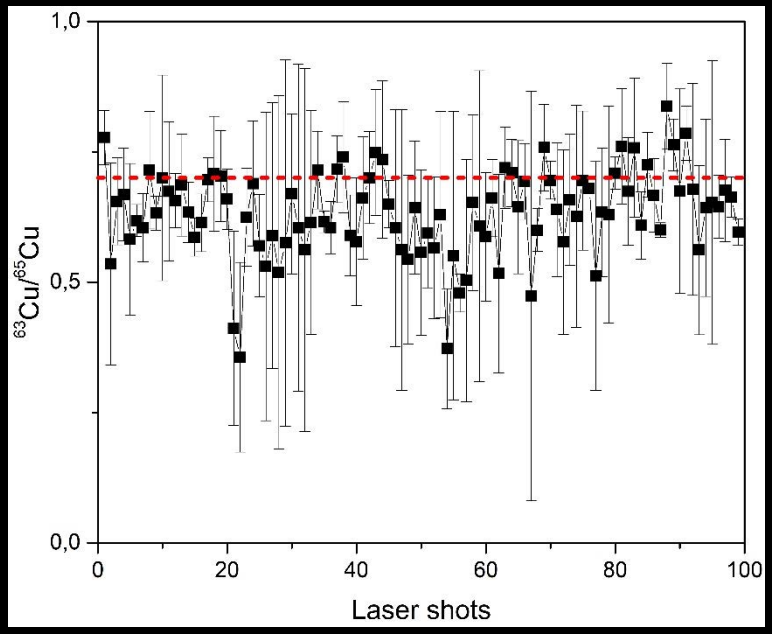


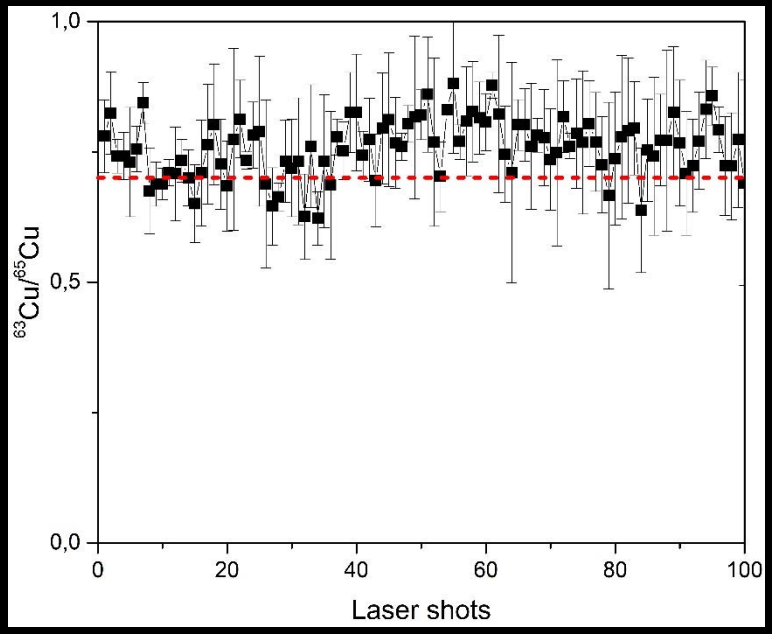
Weird things ...



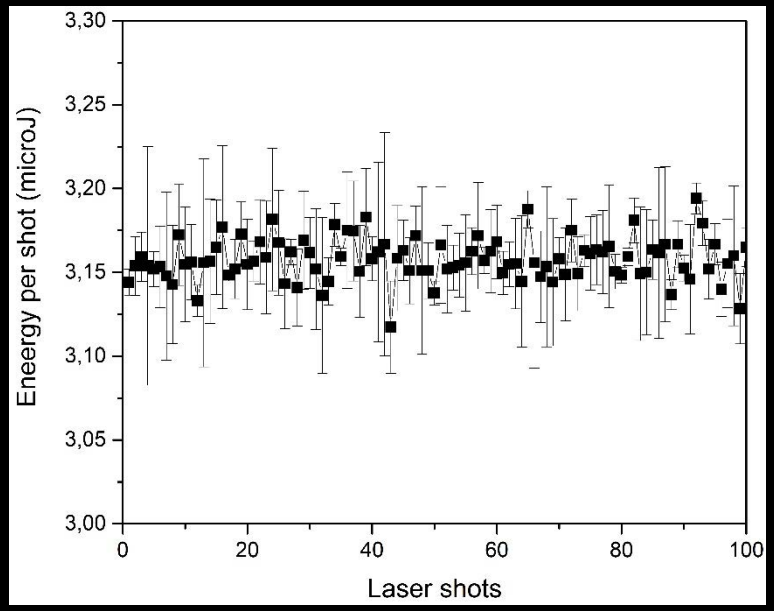


Weird things ...

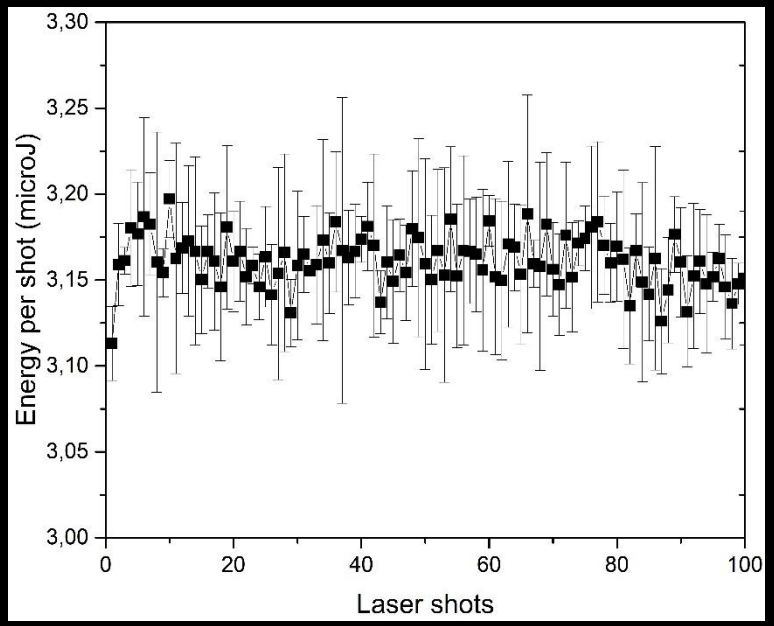




Weird things ...

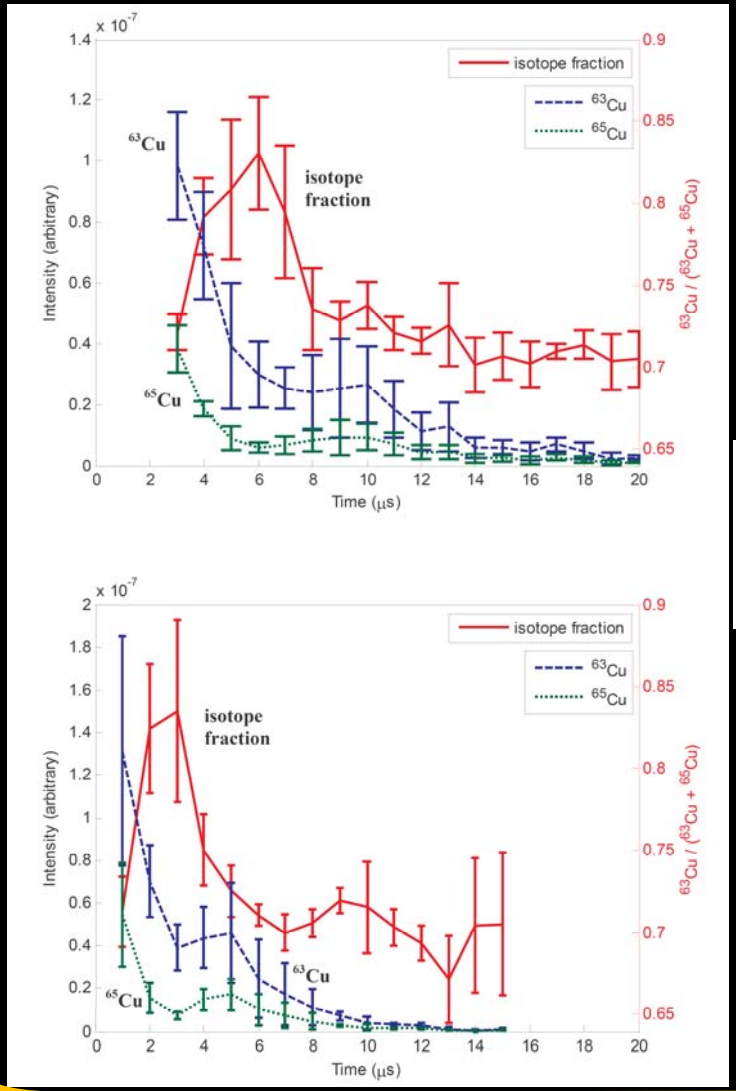


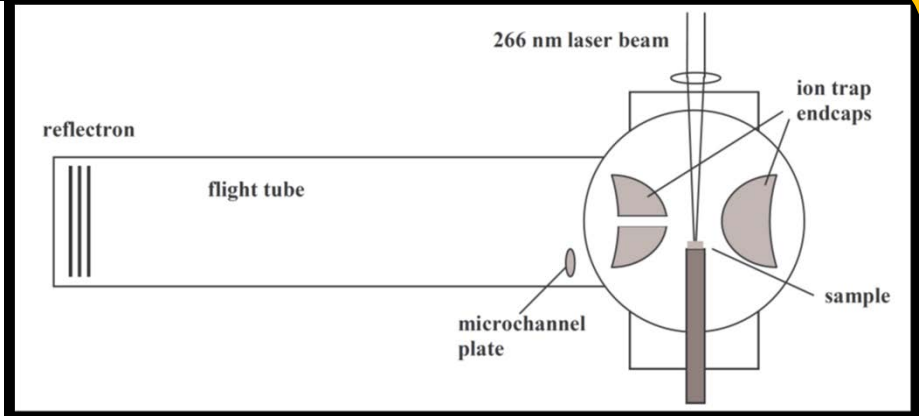
RSD: 0.42%



RSD: 0.44%

Weird things ...

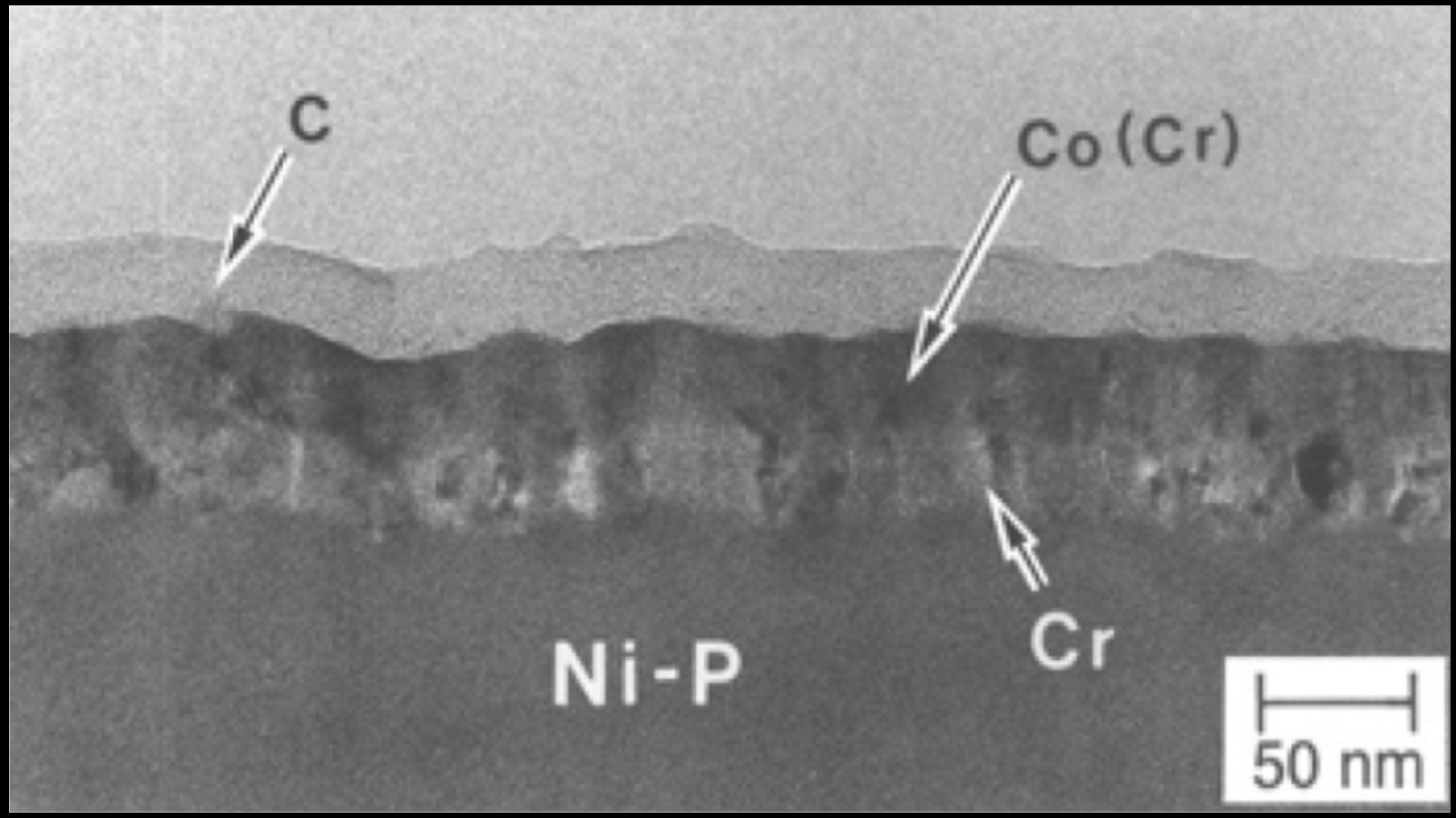


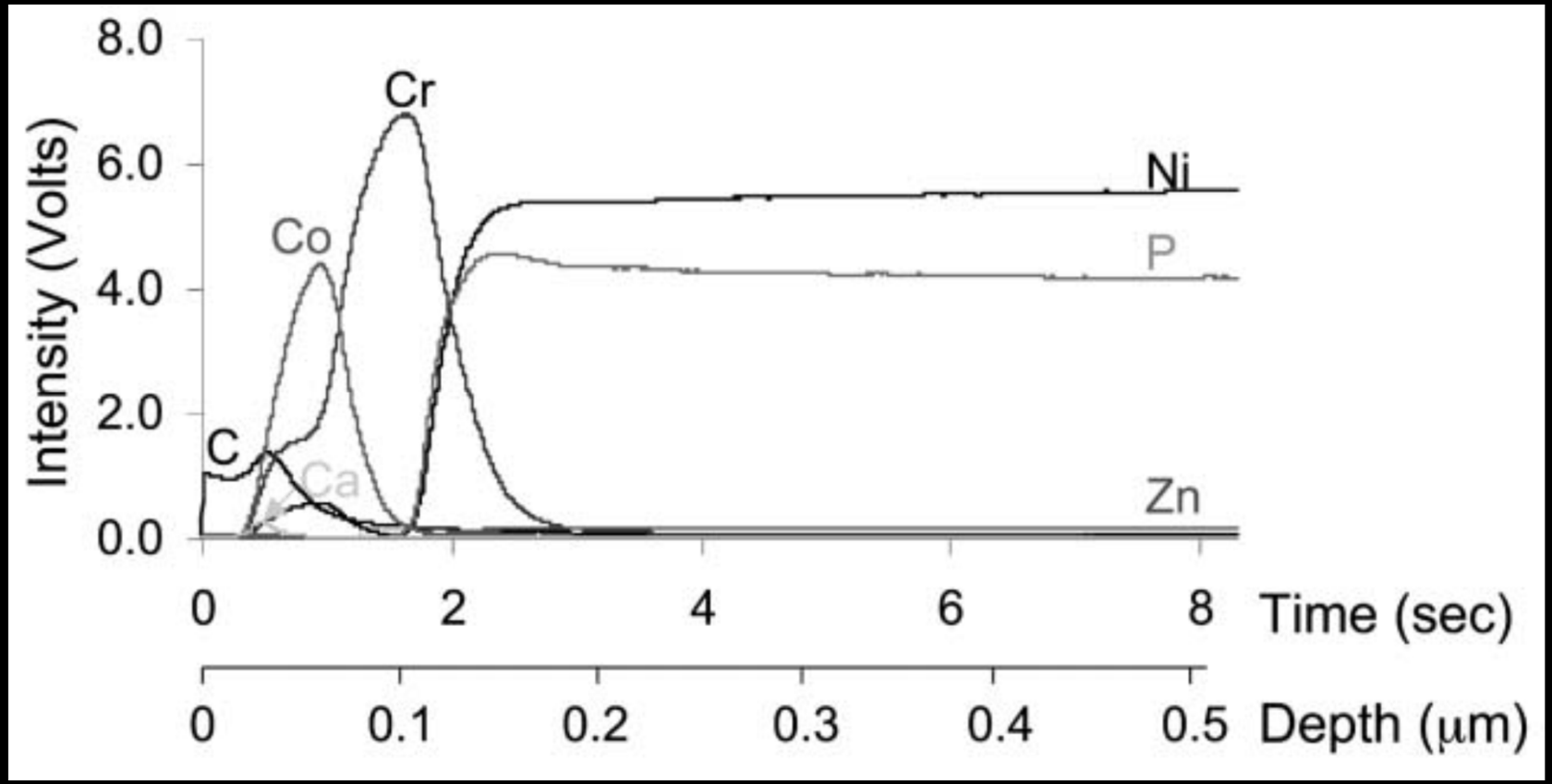


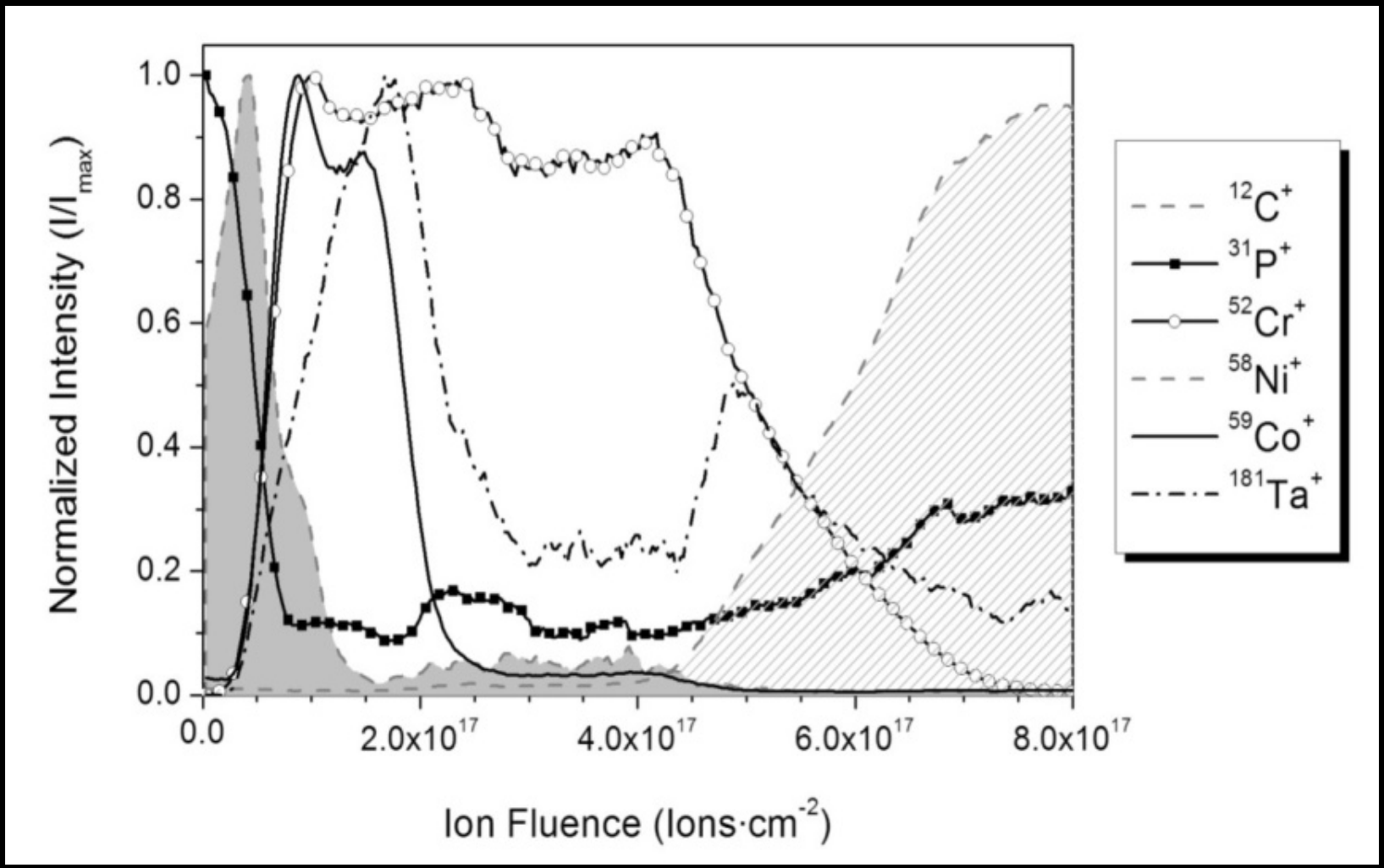
Separation of Copper Isotopes in the Laser Plume

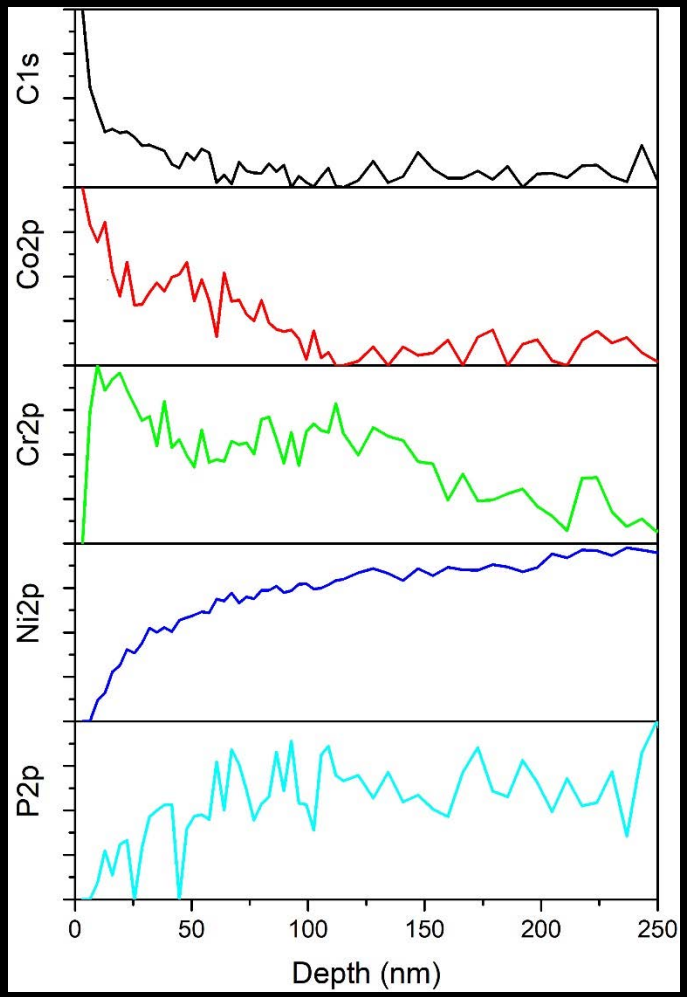
Timothy Wu Suen, Xianglei Mao, and Richard E. Russo

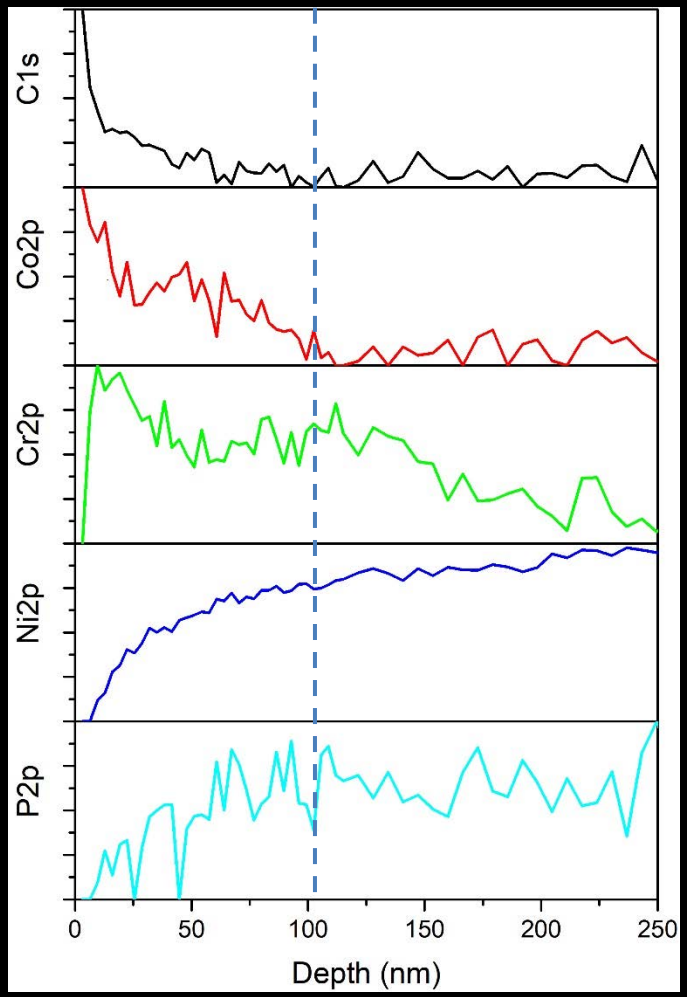
CP1278, *International Symposium on High Power Laser Ablation 2010,* edited by C. R. Phipps

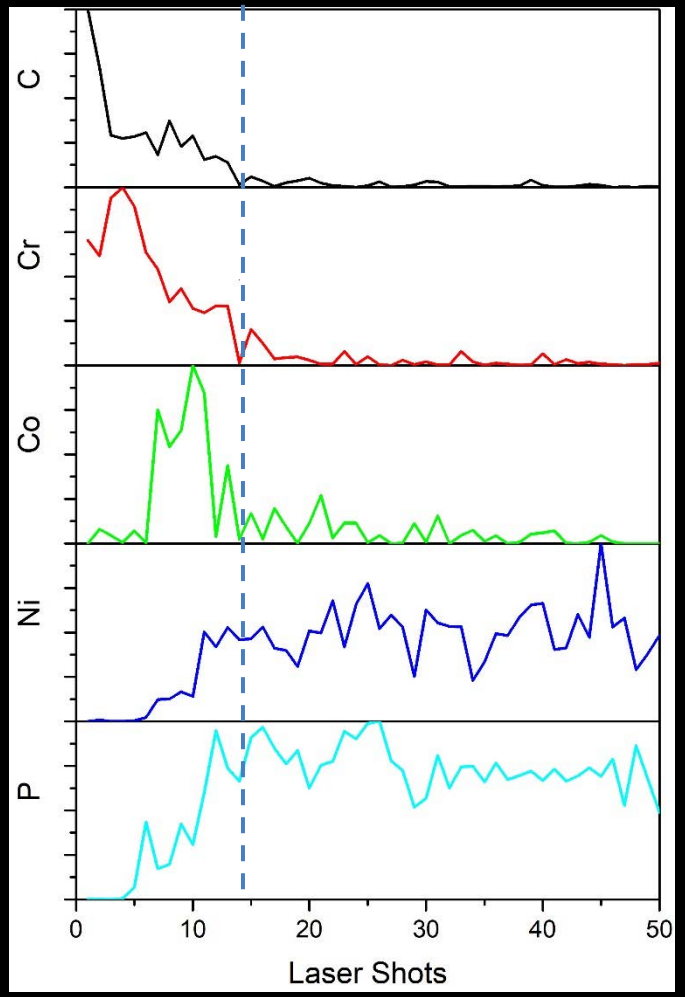

C
Co(Cr)
Cr
Ni-P
50 nm

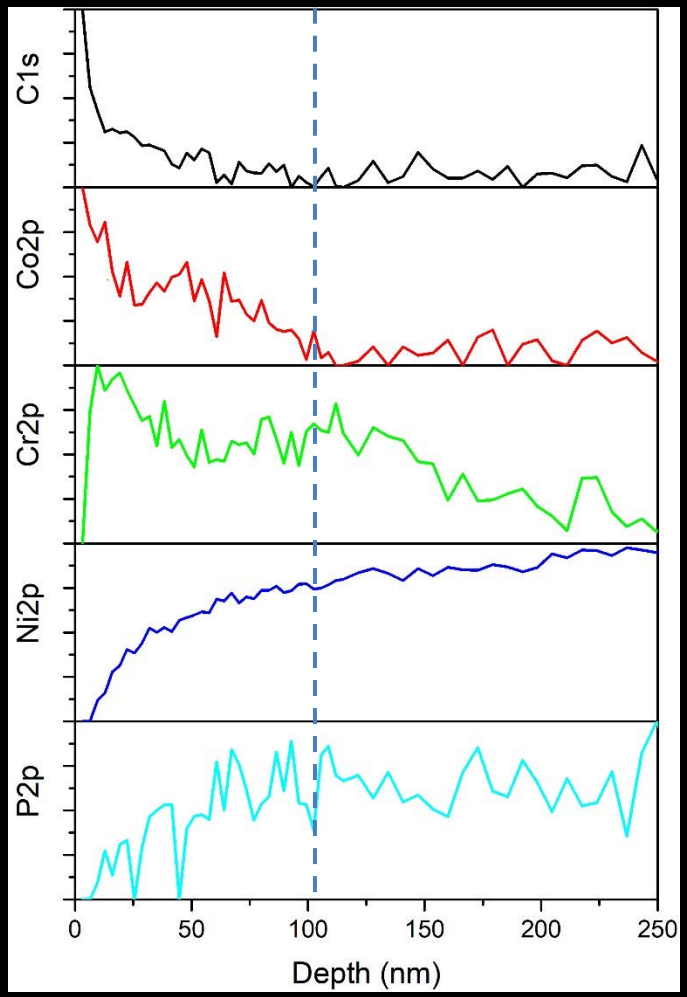

Intensity (Volts)
8.0
6.0
4.0
2.0
0.0
Cr
Co
C
Ca
Ni
P
Zn
0
2
4
6
8
Time (sec)
0
0.1
0.2
0.3
0.4
0.5
Depth (μm)

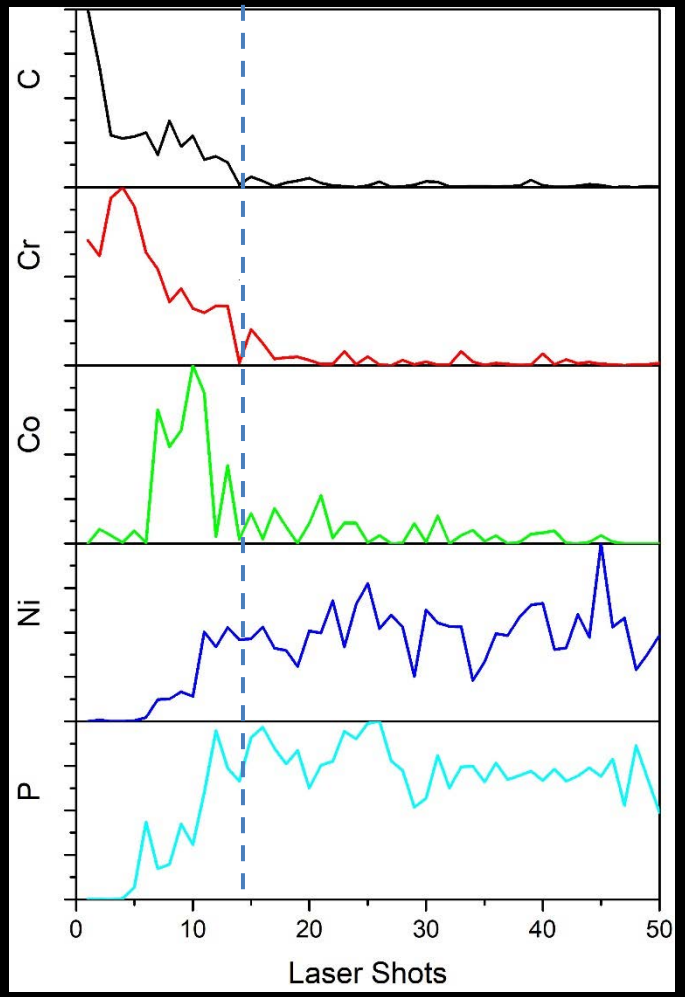

Normalized Intensity (I/I$_{max}$)
1.0
0.8
0.6
0.4
0.2
0.0
0.0
2.0x10^{17}
4.0x10^{17}
6.0x10^{17}
8.0x10^{17}
Ion Fluence (Ions·cm^{-2})
$^{12}C^{+}$
$^{31}P^{+}$
$^{52}Cr^{+}$
$^{58}Ni^{+}$
$^{59}Co^{+}$
$^{181}Ta^{+}$


C1s
Co2p
Cr2p
Ni2p
P2p
0
50
100
150
200
250
Depth (nm)

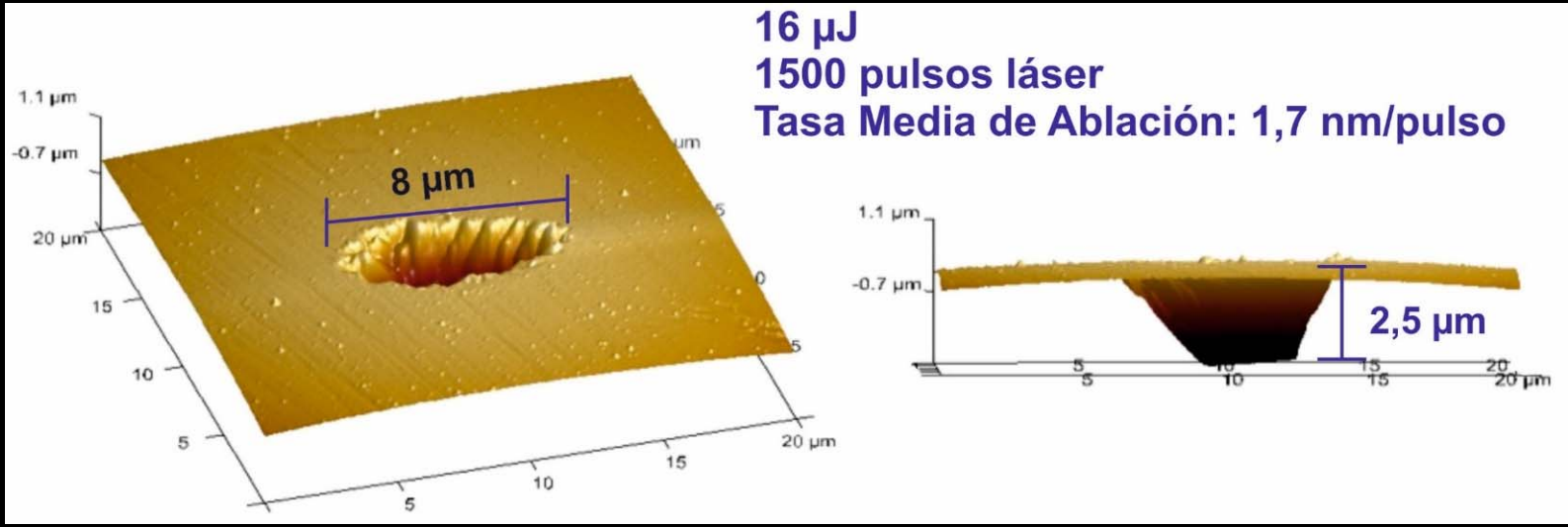

C1s
Co2p
Cr2p
Ni2p
P2p
0
50
100
150
200
250
Depth (nm)


C
Cr
Co
Ni
P
0
10
20
30
40
50
Laser Shots





AAR aprox. 7 nm/pulse

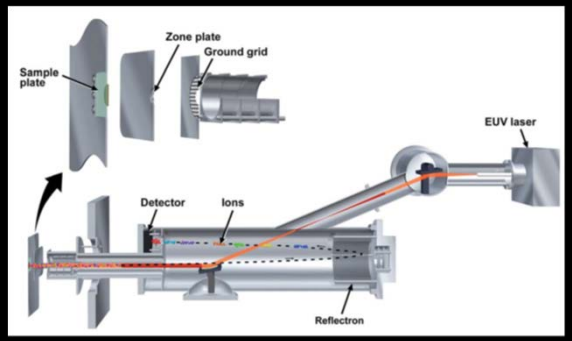


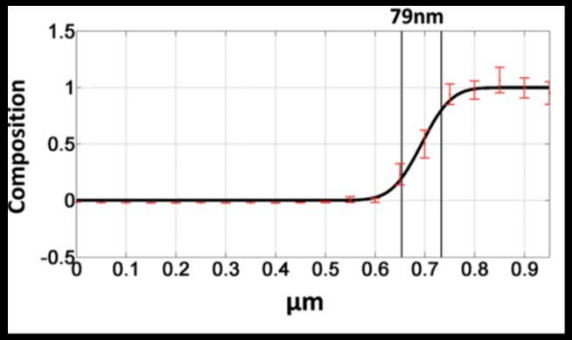
Energy/pulse (µJ)		AAR (nm/pulse)
21		2,174
16		1,682
11	2,433	1,622

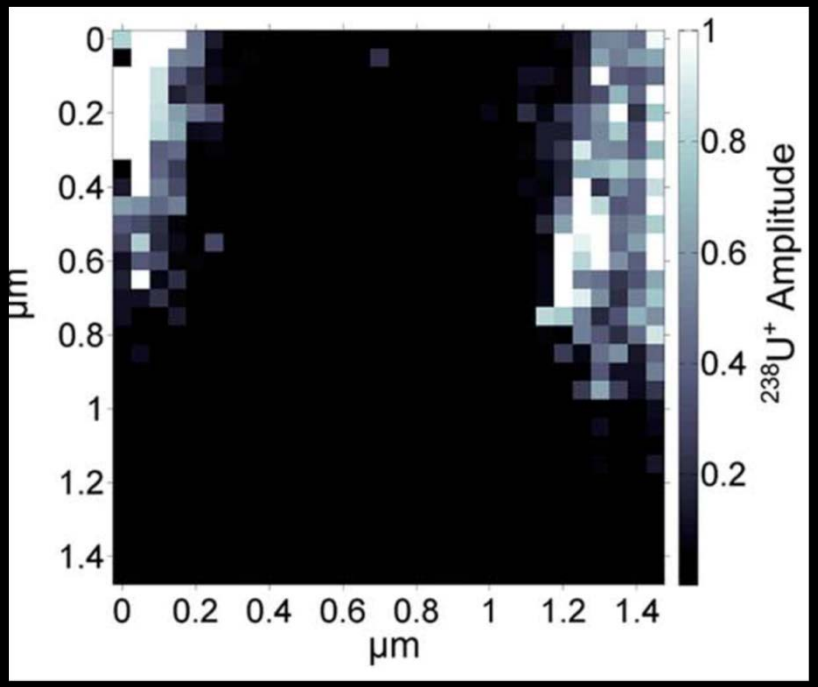
Cite this: *J. Anal. At. Spectrom.*, 2017, **32**, 1092

Characterization of extreme ultraviolet laser ablation mass spectrometry for actinide trace analysis and nanoscale isotopic imaging

Tyler Green,[a] Ilya Kuznetsov,[a] David Willingham,[b] Benjamin E. Naes,[b] Gregory C. Eiden,[b] Zihua Zhu,[b] W. Chao,[c] Jorge J. Rocca,[a] Carmen S. Menoni[a] and Andrew M. Duffin*[b]

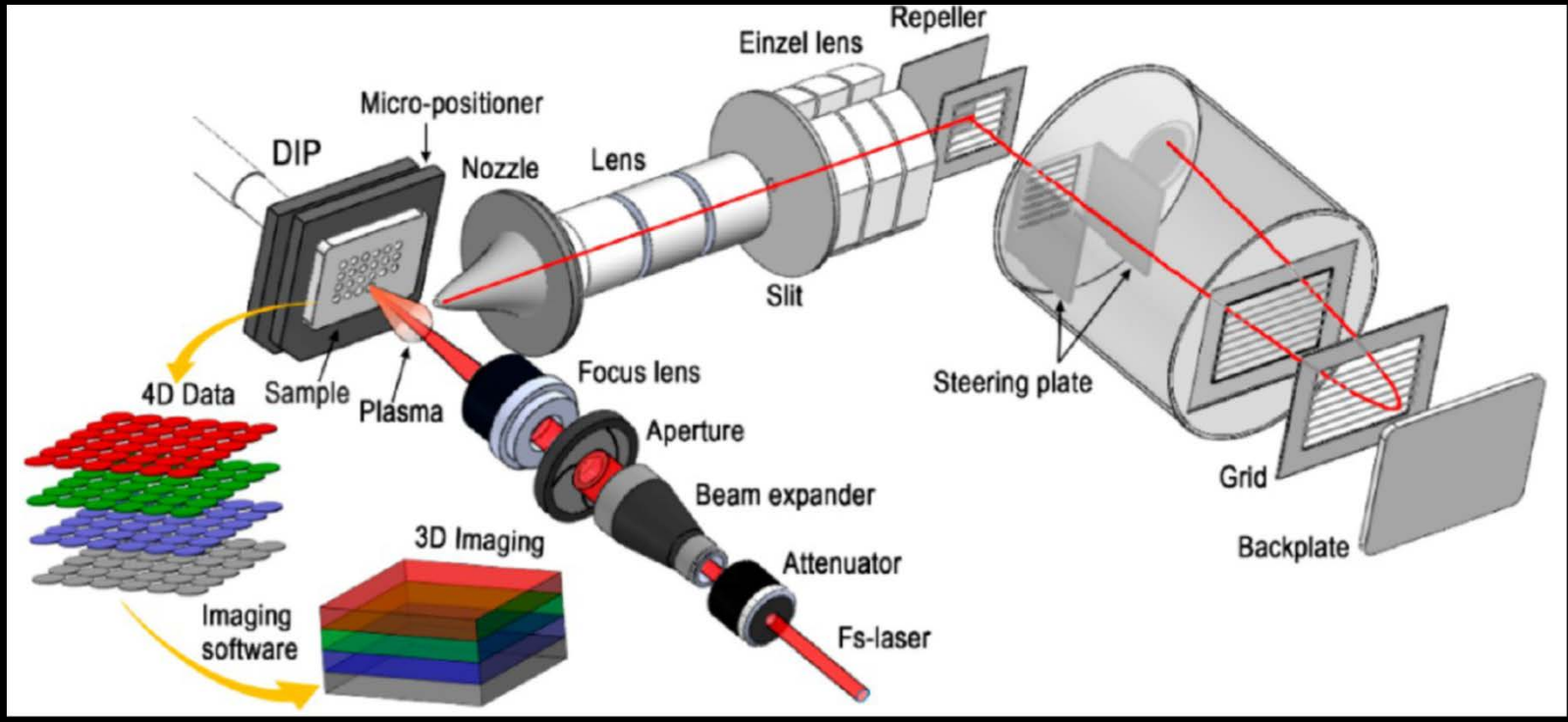






Three-Dimensional Elemental Imaging of Nantan Meteorite via Femtosecond Laser Ionization Time-of-Flight Mass Spectrometry

Miaohong He,[†] Yifan Meng,[†] Shanshan Yan,[†] Wei Hang,[*,†,‡] Wenge Zhou,[§] and Benli Huang[†]



Three-Dimensional Elemental Imaging of Nantan Meteorite via Femtosecond Laser Ionization Time-of-Flight Mass Spectrometry

Miaohong He,[†] Yifan Meng,[†] Shanshan Yan,[†] Wei Hang,[*,†,‡] Wenge Zhou,[§] and Benli Huang[†]

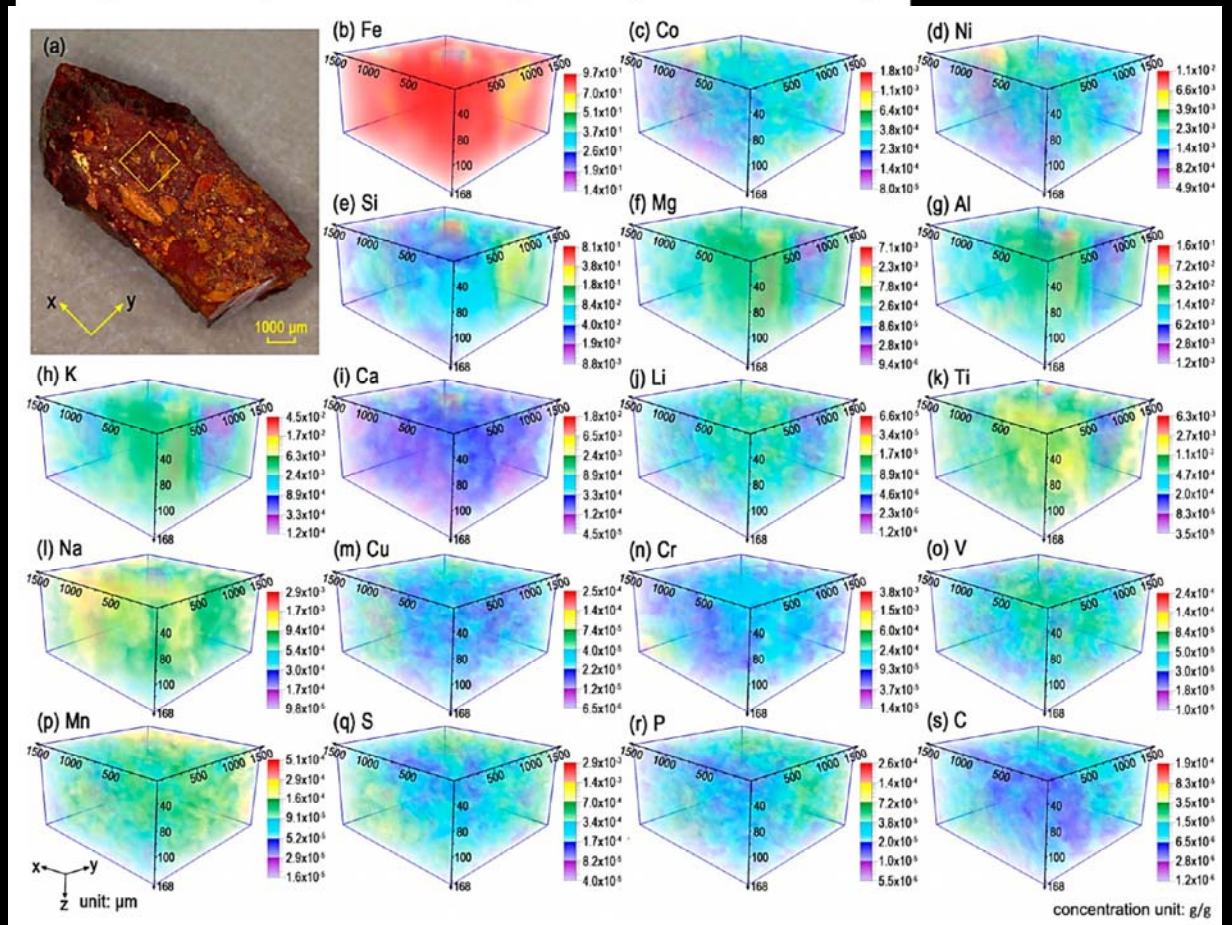
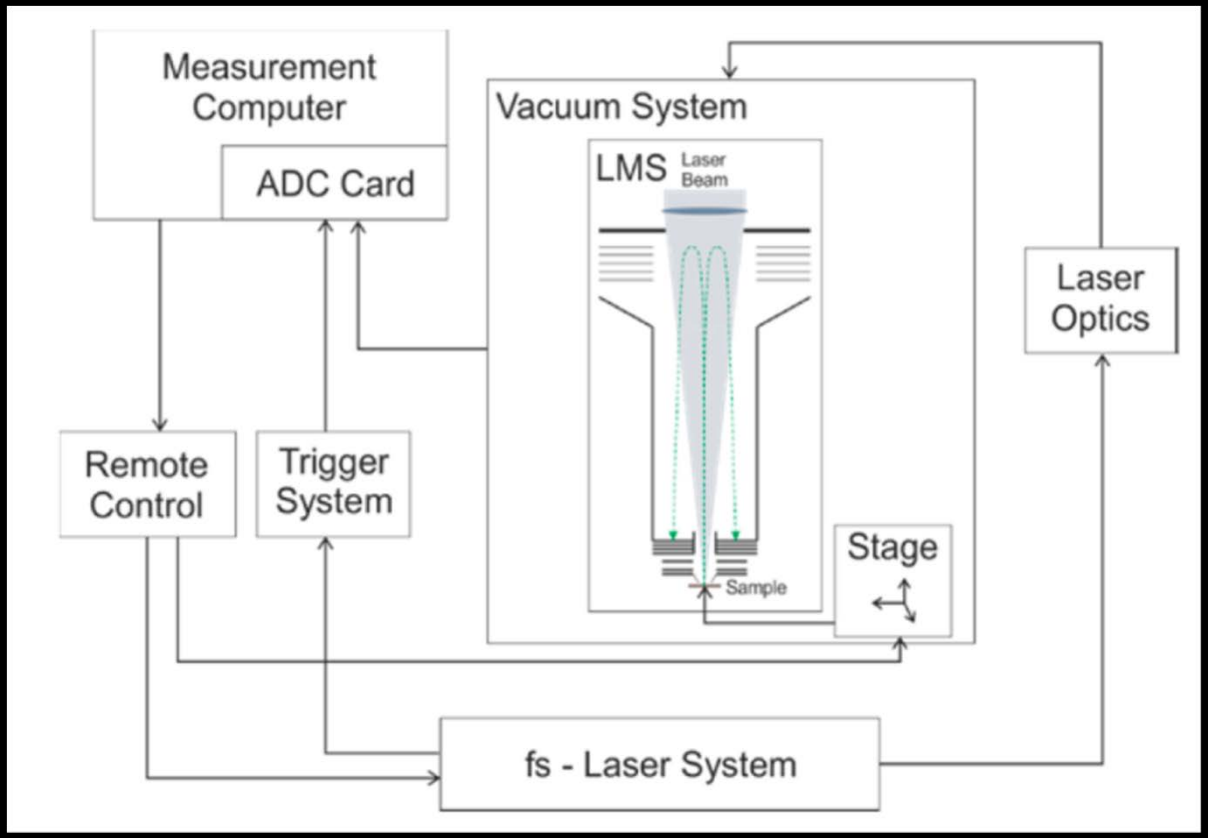


Figure 5. 3D element distributions recorded in the Nantan meteorite. The dimensions of the area are 1.5 × 1.5 mm^2. (a) Photograph of the meteorite and (b–s) particular elemental distributions in the meteorite (g/g in concentration).

Toward Three-Dimensional Chemical Imaging of Ternary Cu–Sn–Pb Alloys Using Femtosecond Laser Ablation/Ionization Mass Spectrometry

Valentine Grimaudo,[†] Pavel Moreno-García,[†] Andreas Riedo,[*,‡] Stefan Meyer,[‡] Marek Tulej,[‡] Maike B. Neuland,[‡] Miklós Mohos,[†] Christoph Gütz,[§] Siegfried R. Waldvogel,[§] Peter Wurz,[‡] and Peter Broekmann[†]



Toward Three-Dimensional Chemical Imaging of Ternary Cu–Sn–Pb Alloys Using Femtosecond Laser Ablation/Ionization Mass Spectrometry

Valentine Grimaudo,[†] Pavel Moreno-García,[†] Andreas Riedo,[*,‡] Stefan Meyer,[‡] Marek Tulej,[‡] Maike B. Neuland,[‡] Miklós Mohos,[†] Christoph Gütz,[§] Siegfried R. Waldvogel,[§] Peter Wurz,[‡] and Peter Broekmann[†]

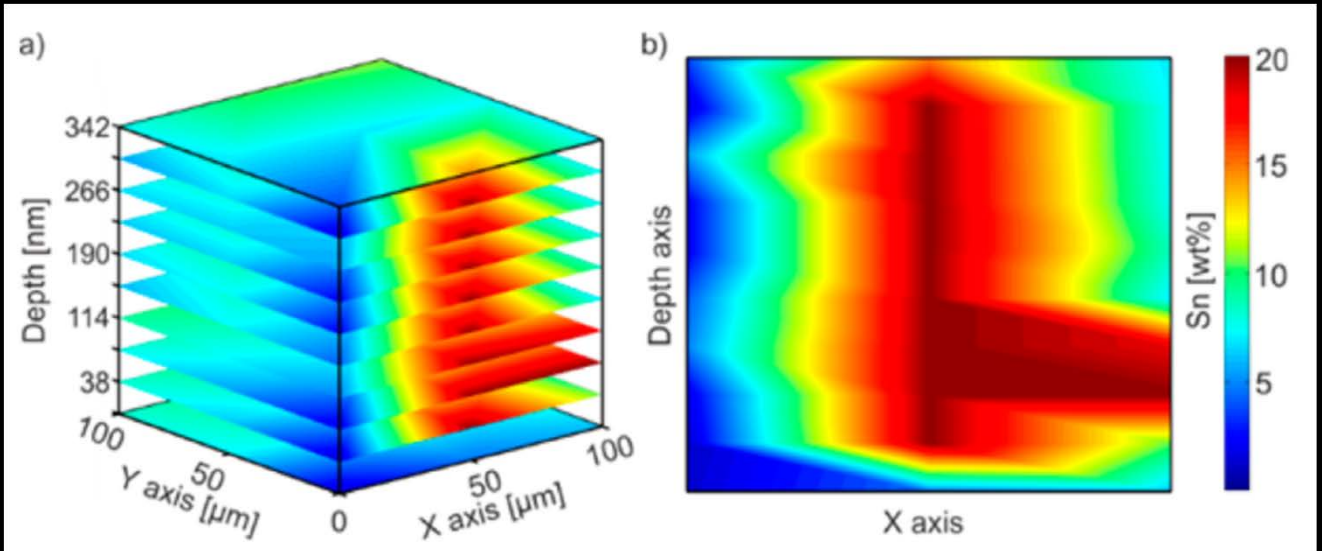


Figure 8. Tin-rich grain in the CuSn10Pb10 sample observed over 3 × 3 spots of the raster array and 10 consecutive depth layers (accumulated mass spectra): (a) slice plot illustrating the grain inside the Cu matrix; (b) *X*/depth interpolation of the 10 layers.

Take-home notes ...

LIMS maybe is not a SST, but may face almost any problem related to condensed-phase

Under well-controlled conditions, extraordinary results come out, comparable to well-established techniques

Laser-induced ions, even at a low-fluence regime are horses difficult to be saddled, introducing large inhomogeneities in the measurements, but not as large to impair the generation of results of quality

New groups of laser spectroscopists with strong mass spec background are demonstrating that LIMS can be as good as many other solid-analysis techniques. It is just a matter of perseverance and solid backgrounds.