INVESTIGATION OF THE SPATIAL AND TEMPORAL DISTRIBUTION OF PLASMA EXCITED SPECIES PRODUCED IN LASER ABLATION-GLOW DISCHARGE

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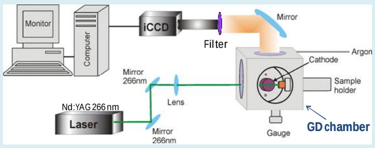
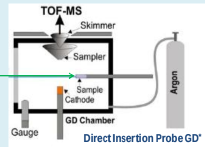
INTRODUCTION

The combination of Laser Ablation (LA) as sampling technique with pulsed Glow Discharge (GD) as post ionization/excitation source has been examined over the last years. Since sampling and ionization steps are spatially and temporally separated they can be independently optimized, offering less matrix dependence. Furthermore LA provides the possibility of high lateral resolution, and both conductors and insulating materials can be analyzed (radiofrequency powered GD is not necessary). When coupling LAGD to optical emission spectroscopy (OES), enhancement factors up to 5 have been reported for the emission of the ablated material in comparison to the emission signal directly generated by LA [1, 2]. Mass spectrometric studies have shown also the capabilities of the GD to ionize the ablated material [3]. In particular, the use of a Time of Flight Mass Spectrometer (TOFMS) allows quasi-simultaneous analysis of elemental and molecular information when the aerosol is injected at certain temporal regimes in a pulsed GD [4, 5]. However, further research is still needed in order to fully understand the processes involved in the LA-GD interaction.

In this sense, OES would allow to visualize the expanding plasma plume. Therefore, in this work, an in-house developed LA ms-pulsed GD-TOFMS instrument[3] has been adapted to allow the spatial and temporal characterization of the different species by OES. An iCCD provided with an objective has been used to obtain 2D images of the emission within the region defined by sample, cathode and anode, at different temporal domains during the GD pulse (prepeak, plateau and afterglow). Optical bandpass filters have been used to select the wavelength range of interest in order to evaluate Al, Cu and Ar emission (sample ablated material, cathode sputtered material and filling gas, respectively).

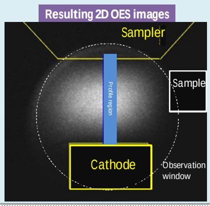
EXPERIMENTAL SET-UP



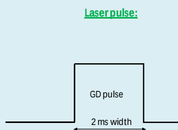


Simultaneous MS and OES measurements

Resulting 2D OES images



EXPERIMENTAL CONDITIONS



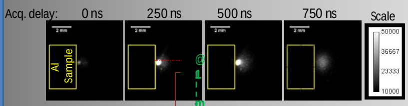
LAGD EXPERIMENTAL CONDITIONS	
Cathode-anode distance	10 mm
Cathode material	Copper
Sample material	Aluminum
GD voltage	700V
Ar pressure	0.8 mbar
GD pulse width	2 ms
GD & Laser frequency	10 Hz
Laser energy	0.5-0.7 mJ

BANDPASS FILTERS	
765 nm	Ar I 763.51 nm
794 nm	Ar I 794.82 nm
810 nm	Ar I 800.62 nm, Ar I 801.48 nm, Ar I 810.37 nm, Ar I 811.53 nm
410 nm	Ar II 410.39 nm, Ar II 413.17 nm
510 nm	Cu I 510.55 nm
400 nm	Al I 396.15 nm

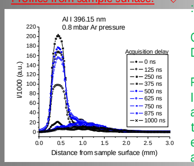
* M. Tarik, G. Lotito, J.A. Whitby, J. Koch, K. Fuhrer, M. Gonin, J. Michler, J.L. Bolli, D. Gunther, Spectroc. Acta B, 64 (2009) 262-270.

LA plume. Al I 396.15 nm (400 nm filter)

Dynamics of the LA plume



Profiles from sample surface:

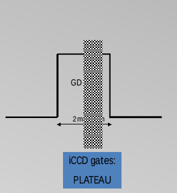


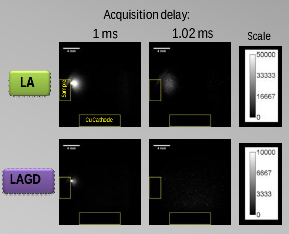
125 ns gate width

➢ Fast evolution of the emission of the LA plume.

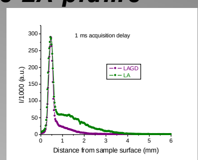
➢ Very confined close to the sample surface.

Influence of GD on the LA plume

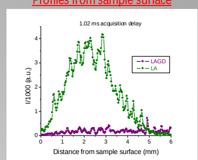




20 ms gate width



Profiles from sample surface

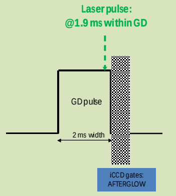


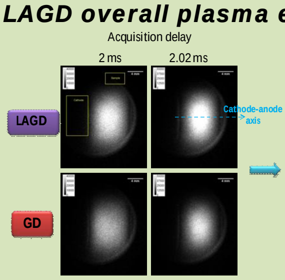
➢ Suppression of the LA signal!!

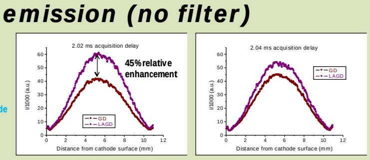
➢ Not due to plasma shielding

➢ No effect on the ablation

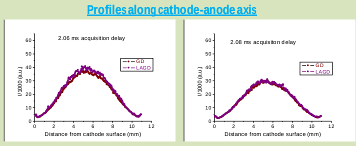
LAGD overall plasma emission (no filter)







Profiles along cathode-anode axis



Acquisition delay

Laser pulses between 1.90 and 1.98 ms

	Maximum Relative Enhancement (%)				
	1.90 ms	[illegible]	1.94 ms	1.96 ms	1.98 ms
2.04ms	20	[illegible]	25	10	0
2.06ms	10	[illegible]	20	5	0
2.08ms	0	[illegible]	10	0	0

← Laser pulse delay

Coincident with GDOES afterpeak delay

It takes 100 ms to observe the maximum after LA in the central region of the GD

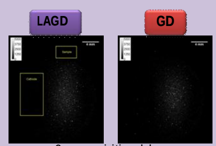
➢ **Enhancement only observed when firing the laser close to GD pulse termination, and measuring during afterglow.**

➢ **No enhancement observed when firing the laser and measuring during GD prepeak or plateau.**

"Who" is being enhanced?

Laser shot @1.9 ms

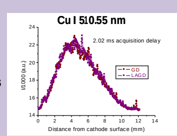
Al I 396.15 nm (400 nm filter)

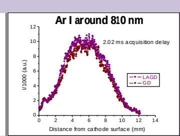


2 ms acquisition delay

➢ No enhancement of the Al resonance line during the afterglow, or within the plateau!!

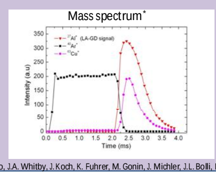
GD species





➢ Emission from GD species is not affected after the LA event!!

Al ions by MS



➢ Al ions are being produced and detected during the afterglow!

➢ The enhanced emission is due to more energetic transitions (from more excited Al atoms)??

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CONCLUSIONS

❖ Aluminium emission from LA is suppressed when the GD is on (prepeak or plateau) → possible effect of the electrons on the LA plume?

❖ No aluminium emission at 396.15 nm is detected within the cathode-anode region after the ablation process (neither during plateau nor during the afterglow)

❖ Copper and argon species (GD species) are not affected by the LA process that take place before.

❖ The overall LAGD plasma emission is enhanced up to 65 % respect to the GD plasma emission.

- The maximum enhancement is recorded 20 ms after pulse termination (GD afterpeak)
- It takes about 100 ms to observe this maximum within the cathode-anode central region, after the ablation process.

References

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