

# Time and space-resolved spectroscopic and imaging study of a laser-produced swine muscle tissue plasma

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**Synopsis** We investigated the optical emission and imaging features of plasmas produced by a high-power transversely excited atmospheric CO<sub>2</sub> laser pulses on a swine muscle tissue sample in different vacuum conditions. The analyzed plasma shows electronically excited neutral Na, K, C, Mg, H, Ca, N, and O atoms, ionized C<sup>+</sup>, C<sup>2+</sup>, C<sup>3+</sup>, Mg<sup>+</sup>, Mg<sup>2+</sup>, N<sup>+</sup>, N<sup>2+</sup>, Ca<sup>+</sup>, O<sup>+</sup>, and O<sup>2+</sup> species and molecular band systems of CN, C<sub>2</sub>, CH, NH, OH and CaOH. Time-resolved 2D emission spectroscopy is employed to study the expanded distribution of several species ejected during ablation. The expansion of the plume front was analyzed using Shock wave and Drag models.

Laser-produced plasmas (LPPs) are currently a topic of great interest in fundamental and applied areas such as fabrication of thin films by pulsed laser deposition, production of nanoparticles, spectrochemical analysis through laser-induced breakdown spectroscopy (LIBS) [1], ion source etc. Beyond traditional applications of LIBS, recent progresses lead to analysis of biological warfare agents and animal tissues.

In this work, we present a spatial and temporal analysis of the LPP plume generated on a biological tissue target. Time-resolved 2D emission spectroscopy is used to study the expanded distribution of different species ejected during ablation. Fig. 1 shows a schematic overview of the temporal history of the LPP sample. The temporal shape of the CO<sub>2</sub> laser pulse is also shown. Inset plots illustrate some space-resolved spectral images observed at different delays for a gate width time of 100 ns. The recorded spectral intensity is indicated by a pseudo-color. By tracking the maximum brightness displacement for different plasma species gives their average expansion velocities.

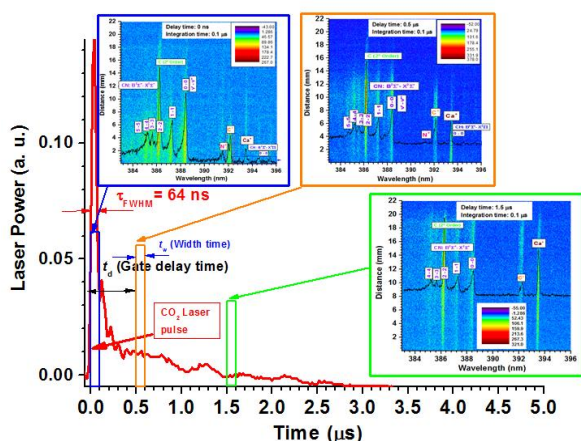


Fig. 1. Schematic overview of the temporal and spatial evolution of the LPP sample.

The expansion velocities of the ionized species towards the longitudinal direction are found to be increasing with degree of ionization. Plasma parameters such as electron density and temperature were measured from the spatial-temporal analysis of different specific species.

We used the imaging data to create position-time plots (Fig. 2) of the shockwave front at several background air pressures. The solid line represents the shockwave model fit. These images provide very useful information about the expansion and internal structure of the plasma-plume. Surface morphology of irradiated surface showed that increasing the pressure of the ambient gas, decreased the ablated mass.

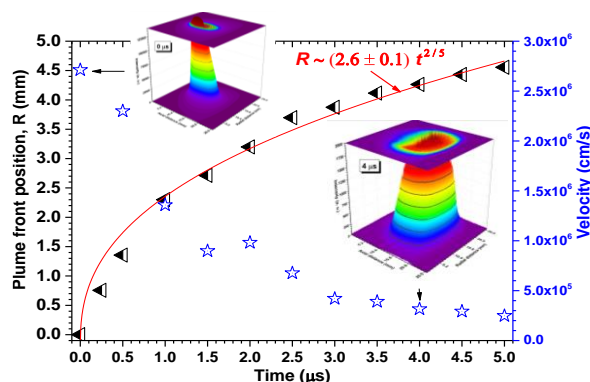


Fig. 2.  $R$ - $t$  plot and velocities for the expanding plume front in vacuum (0.01 Pa). Insets show two images (0 and 4  $\mu$ s) at 1.1 GW/cm<sup>2</sup> incident laser power density.

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## References

[1] J. J. Camacho *et al* 2013 *Spectrochimica Acta Part B* **88** 203.

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