# Tuning emission properties of laser-produced plasmas using beam shaping techniques

Girum A. Beyene*, Oleksandr Gatsa, Jijil JJ Nivas, Inam Mirza, and Alexander V. Bulgakov

Institute of Physics of the Czech Academy of Sciences, Na Slovance 1999/2, 182 00, Prague 8, Czech Republic
*Corresponding author email: girum.beyene@fzu.cz

Laser-produced plasmas (LPPs) serve as efficient sources of light (e.g. laser-induced breakdown spectroscopy (LIBS)) and species for nanoparticle generation. The optical emission properties of LPPs, such as spectral output and radiative efficiency, are critically influenced by the initial laser-plasma dynamics [1]. Advanced beam shaping techniques provide a powerful methodology for modulating these emission characteristics by precisely tailoring the spatial and temporal profiles of the driving laser pulses. In this study, we demonstrate the use of a diffractive optical element (DOE) for splitting the laser beam and an S-wave plate for doughnut shaping the beam as powerful tools to control the emission characteristics of laser ablation plumes of metallic and non-metallic targets, particularly focusing on the potential to enhance the analytical capabilities of LIBS. We investigated the plume characteristics of Cu and Si plasmas using time-resolved optical emission spectroscopy, time-resolved imaging, and planar Langmuir ion probe-based signals. By splitting a Gaussian beam (Nd:YAG, 1064 nm, 5 ns, ~ 50 mJ) into 4 sub-beams using a 2x2 DOE, the spectral emission intensity of Cu showed significant enhancement compared to a single beam with the same total laser energy. In addition, the ion time-of-flight signal indicates the existence of additional peaks, potentially resulting from the plume interaction of the sub-beams. These findings open the potential for advanced beam shaping as a promising approach for tuning the optical emissivity and particle kinetic energies of laser-produced plasmas for LIBS and thin film deposition applications.

**Acknowledgements**:
Work supported under MSCA co-funded by the European Union (Physics for Future – Grant Agreement No. 101081515).

**References**:

[1] A. Li, S. Chai, H. Peng, Z. Zhao, J. Ren, et al., Analytical Chemistry, 97, 3253−3262 (2025)