Plasma processes and emission spectra in laser induced plasma

A. De Giacomo[1*], M. Dell'Aglio[2], O. De Pascale[2], R. Gaudiuso[1], G. Valenza[1]

[1] *Department of Chemistry, University of Bari, Bari, Italy*
[2] *CNR-IMIP, Bari, Italy*
Contact email: alessandro.degiacomo@uniba.it

Laser Induced Plasmas (LIPs) is getting a growing interest in the scientific community, due to their high impact in different fields of science including analytical chemistry, material science, laser ignition, laser propulsion and several medical applications. The investigation of LIPs from the fundamental point of view is very complex, due to their nature of transient plasmas. This implies that fluid-dynamic aspects must be taken into account, as well as plasma chemistry ones, together with the correlation between laser-matter interaction and plasma formation [1].

When a laser pulse with irradiance of 0.1-10 GW/ cm^2 is focused on a sample, the breakdown occurs and a dense atomic plasma is produced. The produced plasma evolution is mainly driven by the expansion of the plasma against the surrounding environment. During the expansion, gas temperature and consequently electron temperature decrease, and so does the number density of all the particles, thus perturbing the hierarchy of elementary processes in the plasma In order to simplify the all phenomena involved in LIP evolution, three main stages have been identified and discussed in details: high density plasma, near equilibrium plasma and non-equilibrium plasma including molecular formation [2]. In this frame optical emission spectroscopy is the most convenient tool for investigating this kind of systems. Indeed the emission spectra are the results of the particles population distribution among internal levels, the knowledge of the mechanisms taking place during the expansion is extremely important to interpret the spectra and optimize laser plasmas for specific applications.

Finally in this work the correlation between emission spectra features and elementary processes and plasma parameters in LIP will be discussed and some consequent applications in the field of analytical chemistry and of nanotechnology will be shown.

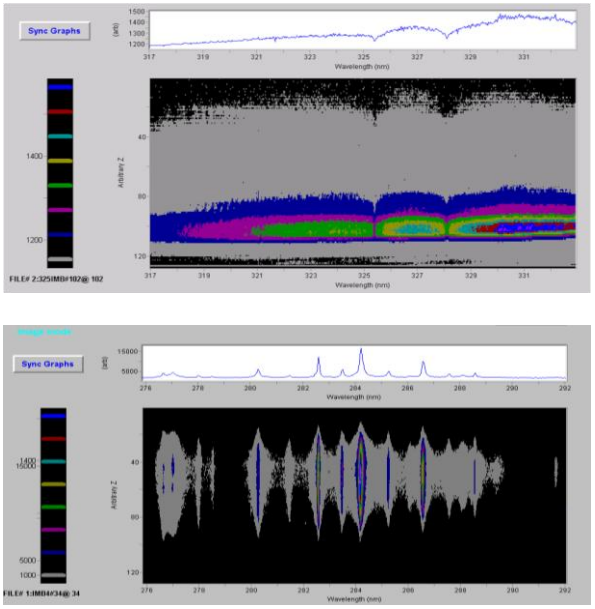

Fig.1. Spectrally resolved images of two characteristic stages of the LIP produced by the interaction of laser with metallic titanium: a) in the first stage of expansion as a consequence of the high electron number density (>10^{19} cm^{-3}) the number of allowable excited level are strongly limited and the spectra is mainly characterized by the continuum radiation; b) during the expansion the electron number density decrease to 10^{18}-10^{17} cm^{-3} and excited levels are populated according to the Boltzmann distribution displaying the typical LTE spectrum.

References:

[1] A. De Giacomo, M. Dell'Aglio, R. Gaudiuso, S. Amoruso, O. De Pascale 2012 Spectrochimica Acta Part B **78** pp 1

[2] A. De Giacomo, M. Dell'Aglio, R. Gaudiuso, O. De Pascale, V. Palleschi, C. Parigger, A. Wood 2014 Spectrochimica Acta Part B **100** pp 180