ABSTRACT

The following dissertation is regarding the parametric study of magnetically confined laser induced Cu and Co plasmas under various experimental conditions. A Q-switched Nd: YAG laser (1064 nm, 10 ns) was employed as an irradiation source to generate Cu and Co plasmas. The two techniques, Optical emission spectroscopy (OES) and Faraday Cup (FC) have been utilized for exploring plasma parameters. All the measurements were carried out in the absence and presence of the transverse magnetic field (TMF) of strength 0.96 Tesla. The plasmas were characterized by using Laser Induced Breakdown spectroscopy (LIBS) technique at lower laser irradiances of 1GWcm^{-2}, 1.2 GWcm^{-2}, 1.3 GWcm^{-2} and 1.5 GWcm^{-2} under different pressures from 5 Torr to 80 Torr of Argon (Ar) & Neon (Ne) and at different time delays ranging from 0.42 μs to 6.67 μs. Whereas, the magnetically confined laser generated Cu and Co plasmas were investigated under vacuum condition by using FC, at laser irradiances of 0.5GWcm^{-2}, 0.6GWcm^{-2}, 0.7GWcm^{-2} &1GWcm^{-2}. The spatially resolved plume dynamics was explored by varying the FC to target distances from 1.2cm, 1.7cm, 2.2cm, 2.7cm to 3.2cm at constant biasing voltage of 90 V. Similarly, the effect of the varying biasing voltages of FC from 60V to 90V was also explored.

LIBS analysis of Cu and Co plasmas revealed the enhancement in emission intensities, electron temperature (T_e) and number density (n_e) at all laser irradiances, under all pressures of Ar & Ne and for all time delays in the presence of magnetic field (B) as compared to field free case. For example, at variable laser irradiances under 30 torr Ar pressure, for field free case, evaluated values of maximum T_e and n_e of Cu plasma are 10263K and 1.1X10^{18}cm^{-3} respectively. Whereas, these plasma parameters of Cu are enhanced to values of 11715K and 1.23X10^{18}cm^{-3} respectively, when magnetic field was employed.

Similarly, with the employment of magnetic field, the Faraday cup measurements of Cu and Co plasmas also revealed and confirmed the significant enhancement in the fluence and Kinetic Energy (K.E) of electrons and ions at all laser irradiances, for various FC biasing voltages and for FC to target distances. For example, the magnetic confinement of Cu plasma is responsible for the enhancement of fluence of plasma electrons from 1.05x10^{12}cm^{-2} (without B) to 3.59x10^{12}cm^{-2} (with B) and plasma ions fluence from 1.18x10^{12}cm^{-2} (without B) to 4.2x10^{12}cm^{-2} (with B). Whereas, K.E of Cu plasma electrons significantly increased from 227eV (without B) to 263eV (with B) and plasma ions from 63.63eV (without B) to 105.25eV (with B).

The higher values of Cu and Co plasma parameters under magnetic field are explainable on the basis of magnetic confinement due to Joule's heating and adiabatic compression. This plasma confinement due to magnetic field is confirmed, by analytically evaluating the values of thermal beta β_t (i.e ratio of pressures of plasma plume to magnetic field) and directional beta β_d having values smaller than one, in all cases. The magnetically confined metallic plasma with enhanced fluence and K.E of charged particles can be used in technologically advanced scientific and industrial applications including ion/electron/electromagnetic radiation sources, table top accelerators and thin film deposition.