The influence of ambient gas on laser produced plasmas and the crater morphology of laser-ablated Al

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Synopsis In this work, the influence of the ambient gas (N_2, O_2, Ar and He) on the plasma emission signal, plasma lifetime, electron number density and temperature, as well as the crater morphology of laser-ablated Al has been studied experimentally.

A laser pulse focused to a sufficiently high irradiance can produce plasma useful for spectrochemical analysis (generally called laser induced breakdown spectroscopy, LIBS). LIBS is generally carried out in the atmospheric pressure in air. Therefore, the laser ablation of solid targets in the presence of a background gas has received increased attention due to its importance in pulsed laser deposition, nanoparticle formation and growth, laser micromachining.

Compared with expansion into a vacuum, the interaction of the plume with an ambient gas is a far more complex gas dynamic process due to the rise of new physical processes involved such as deceleration, thermalization of the ablated species, interpenetration, recombination, formation of shock waves and clustering.

In this work, the influences of the background gas on the emission signal, mass ablation rate, the plasma temperature and the electron number density have been investigated in experiment. The effect of the ambient atmosphere (N_2, O_2, Ar and He) on the plasma parameters and on the emission intensity is found to be maximum in the case of Ar environment.

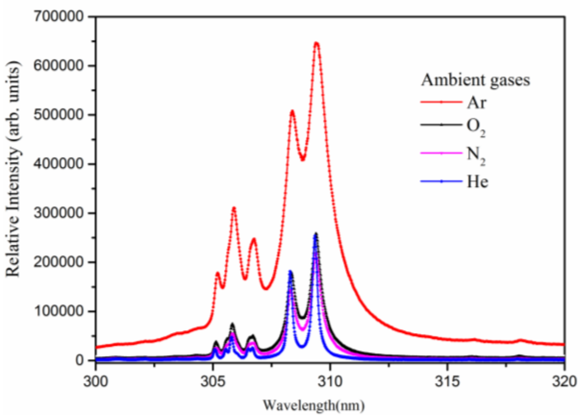

Figure 1. Emission signal of Al plasma detected under different ambient gas, (delay time 300 ns, gate width 200 ns).

We observed that the spectral lines of Al are more intensive, as shown in Fig. 1. Excitation temperature is higher. In addition to, the plasma lifetime is longer in case of Ar condition. However, the influence is in contrast to the case of He condition. The difference of the plasma parameters reveal that the hotter and denser plasmas are formed in an argon atmosphere rather than in helium or others.

Fig. 2 shows the craters after 10 pulses ablation under different surrounding gas. The morphology of crater is quite different, which dependent on the thermalization and shockwave propagation in surrounding gas. Moreover, the ablated efficiency can be obtained from these craters, and the ablated mass under helium is more than that under other gases.

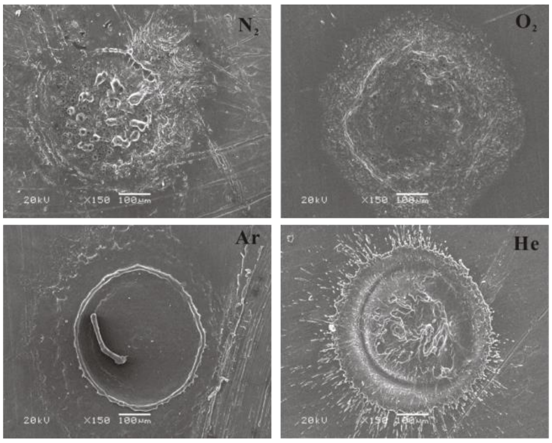

Figure 2. SEM images of crater morphology of laser ablated Al under different ambient gas (10 pulses, 60 mJ/pulse).

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References

[1] S. Bashir *et al.* 2012 *Appl. Phys.* A **107** 203

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