Pulsed Laser Ablation of Liquids for Spectrochemical Analysis: Effects of Laser Wavelength

HO Wing Fat

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Philosophy

April 1997

Hong Kong Baptist University
ABSTRACT

The plasma emissions produced by pulsed (~ 10 ns) laser ablation of liquid jets were monitored for spectrochemical analysis. A Nd:YAG laser at 532 nm and an excimer (ArF) laser at 193 nm, both with energy fluence of 3J/cm², were used to ablate aqueous solution containing sodium, lithium, rubidium and calcium as analytes. By spectroscopically measuring the temperature and electron density of the plasma produced, two different models were gotten for the two laser wavelengths. A typical laser induced breakdown plasma was generated by the 532-nm laser. The ‘hot’ plasma was up to a few eV in temperature and the electron density was in the 10¹⁸ cm⁻³ range. The analyte line emission signals during the initial hundred ns were strongly interfered by the plasma continuum emissions. The desired signals would emerge above the background only when the plasma temperature dropped beneath 1 eV. Since the ionization was thermally induced, the initial intense plasma emission could not be prevented. The signal-to-background ratio could not be significantly improved by either spatial or temporal window techniques because of the inherent instability of jet ablation. In sharp contrast, a ‘cool’ plasma with much lower temperature was produced by the 193-nm laser. The temperature was on the order of fractions of eV. The electron density, however, was comparable to the 532 nm case. The non-thermal ionization process led to relatively dim plasma emissions while the analyte line emission signals were a thousand times stronger. As a result, the 193-nm laser is an ideal ablation source for sampling biologically important elements with emissions in the visible, such as sodium and potassium.
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