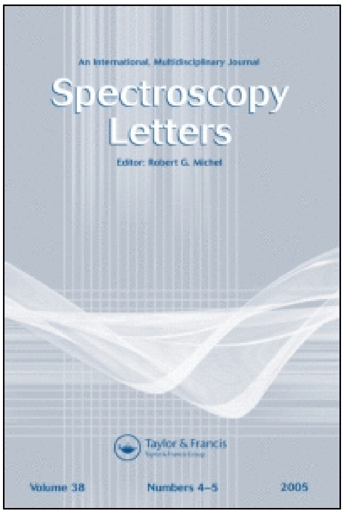


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# Generation of a Low Flow Atmospheric Pressure Neon ICP

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# GENERATION OF A LOW FLOW ATMOSPHERIC PRESSURE NEON ICP

Key Words: Neon, Inductively Coupled Plasma, Emission Spectroscopy

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ABSTRACT

A 27.12 MHz low flow (3 l/min), laminar flow, atmospheric pressure neon ICP has been generated. The forward power used is 500 W with a reflected power of less than 5 W. Using higher powers caused the plasma to either extinguish or form numerous filaments. The $H_\beta$ line is used to determine an electron number density of $8x10^{13}cm^{-3}$. The $N_2^+(0,0)$ and OH(0,0) transitions did not readily emit. This fact, coupled with the low electron density and low input power, indicates a relatively cool plasma.

## INTRODUCTION

A 27.12 MHz Neon Inductively Coupled Plasma (Ne-ICP) has been generated in this laboratory. Argon has long been used as

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the plasma gas for the ICP. Abdallah and Mermet (1) and Chan et al.(2) have generated atmospheric pressure helium plasmas in inductively coupled plasma (ICP) units. Walters et al. (3) generated a reduced pressure (0.5-14 torr) 144 MHz Neon ICP for electrodeless discharge lamp studies. This is the first known report of an atmospheric Ne-ICP. The torch design has been used for He-ICP studies and is described by Manning et al.(4). The Neon ICP is being investigated as a possible atom/ion source for adaptation to a commercial ICP-MS instrument.

## EXPERIMENTAL



The Ne-ICP is generated with a 27.12 MHz RF Plasma Products HFP 5 kW unit (Cherry Hill, NJ). The forward power for the ICP is 500 W with less than 5 W reflected (5). The low flow (3 l/min), laminar flow, atmospheric pressure torch is described by Manning et al.(4). It utilizes an extended quartz sleeve to minimize impurities ($N_2$, $H_2O$, etc.) from the atmosphere entering the plasma. The nebulization system employed is the fritted disk nebulizer (6). The sample is pumped to the fritted disk with a standard peristaltic pump. The flow rate of the plasma gas is 3 l/min with a minimum of 2 l/min and a maximum of 7 l/min possible. The nebulizer gas flow rate is 0.3 l/min with a sample uptake rate of 0.3 ml/min. The nitrogen is seeded in at a rate of 5 ml/min. The neon gas is supplied by Union Carbide-Linde division gas distributors (Albuquerque, NM).

Los Alamos Fourier Transform Spectrometer:

The Los Alamos FTS (7), a national facility for high resolution atomic and molecular spectroscopy, is used in this experiment for medium resolution (0.07 $cm^{-1}$)spectra in the near

IR, visible, and ultraviolet (8500 $cm^{-1}$ to 33372 $cm^{-1}$). Aluminum coated quartz beamsplitters are employed and the detectors utilized are silicon PIN diodes. The number of points taken for each run is 953,863 and the transform size is $2^{20}$(1046000) points. The number of scans is limited by the current availability of research grade neon. The cost of neon is the limiting factor.

## RESULTS AND DISCUSSION

Neons' ionization potential (21.56 eV) is higher than that of argon (15.76 eV) but lower than helium (24.587 eV). This should offer better detection limits for various nonmetals (eg. F, Cl, Br, etc.) verses the argon ICP. The neon plasma as a source does not have the luminosity of the argon ICP and is similar to the helium ICP in this respect. The plasma is stable with powers as high as 1.5 kW. Introducing sample reduces its stability. With an aerosol entering the plasma, it could not operate at powers greater than 600 W. Above this threshold the plasma either extinguished or formed numerous filaments and produced a non-homogeneous plasma. The plasma operated with powers as low as 150 W. Luminosity appears linear with power.

An attempt to measure the rotational temperature using $N_2^+$(0,0) (391.44 nm) and OH(0,0) (306.4 nm) is made. The $N_2^+$ bandhead has a SNR of 4.2 and the R branches used in diagnostics are not discernible making reliable measurements impossible. The OH(0,0) band is not present at all in the spectrum. The $H_\beta$ line is used to measure the electron number density (8) at $8x10^{13}$ $cm^{-3}$. The fact that both species (OH,$N_2^+$), which are strong UV emitters in plasmas and discharges, do not have a readily detectable emission rate, coupled with the low electron density measurement ($8x10^{13}$ $cm^{-3}$)and the low input power (500 W), give reason to believe the Ne-ICP in this setup is cool compared to the argon and helium plasmas (1) run at higher powers. Bands from the first positive system ($B^3 {}_g - A^3 {}_u$) of $N_2$ are obvious in the near IR and visible. This transistion (13,000 $cm^{-1}$- 18,900 $cm^{-1}$)requires less energy for excitation than OH(0,0) (32,700 $cm^{-1}$)or N2+(0,0) (25,600 cm-1).

## CONCLUSIONS

An atmospheric pressure neon ICP is generated. In the current setup it operates reliably at 500 W forward power. The Ne-ICP is being pursued as an atomization source for a commercial ICP-MS setup. It should offer the advantage of "freeing" various mass values that are not accessible with argon as the plasma gas.

## ACKNOWLEDGEMENTS

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