APPLICATION NOTE # 101 PLASMA MONITORING

Introduction:

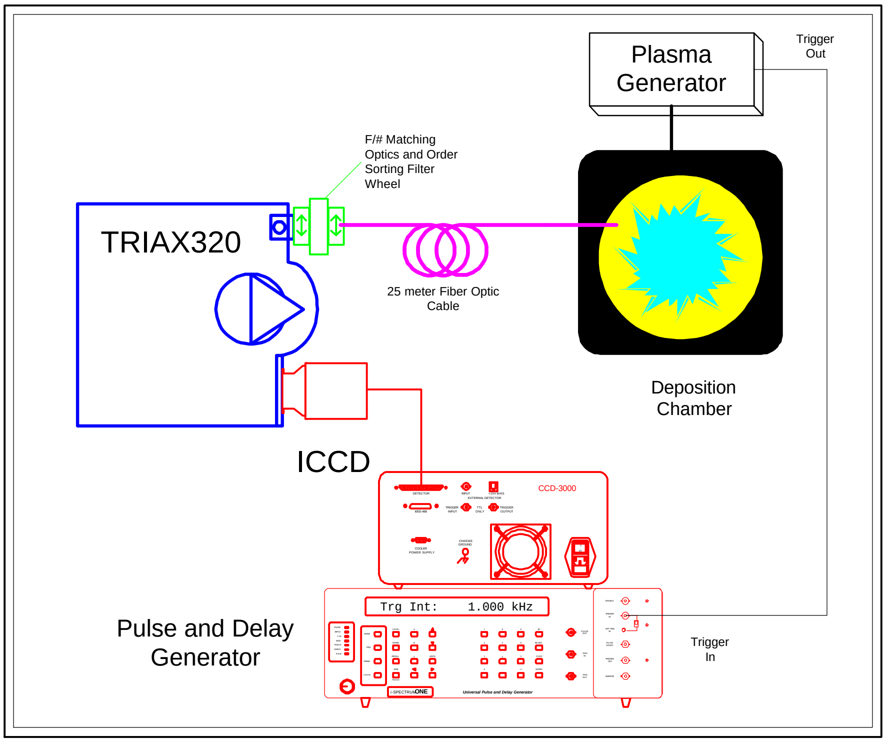
Improvements in Sputtering Deposition systems have led to the use of pulsed plasmas. It is believed that pulsing the plasma causes a temporary increase in electron temperature and that as pulsing frequency increases higher plasma potentials result. Higher plasma potentials cause higher energy ion bombardment of films and thus greater surface mobility of atoms and more thermodynamically favorable film growth. For the systematic study the effects of frequency and duty cycle on pulsed plasmas for sputtering systems, a spectroscopy system was designed using a JY Intensified CCD detector system to study the effects of pulsing parameters on the optical emission spectra.

Experiment:

In sputtering deposition systems, a pulsed plasma is generated in a vacuum chamber. Material from a target inside the chamber is vaporized, and the vapor is deposited on a substrate. The ratio of the gas mixtures in the plasma can be controlled remotely, and affects the deposition rate. The repetition rate and duty cycle of the pulsed plasma generator are also used to adjust the deposition rate and more importantly the quality of deposition.

The plasma is optically monitored using an optical fiber inside the chamber and near to the plasma. The fiber brings the emission light to the entrance of the TRIAX 320 spectrometer for analysis. The spectrometer disperses the light into its individual wavelength components and presents the signal to the i-SpectrumONE ICCD detector. Together, the TRIAX 320 and i-SpectrumONE ICCD detector system can be used to collect either steady-state or time based spectra and provide useful information about the chemical processes inside the plasma chamber which would be difficult to achieve by other measurement means.

Experimental Setup:



Features	Benefits
Complete Integrated Spectroscopy System	Quick Setup Time and Fast Results
Fully Automated Spectrometer	Repeatable and Consistent
Ultra-High Speed Gate Width ICCD	Easily Characterize pulsed plasmas with up to 20 MHz frequencies
Steady State and Time-Domain Measurements	Multiple sets of information Collected with one System

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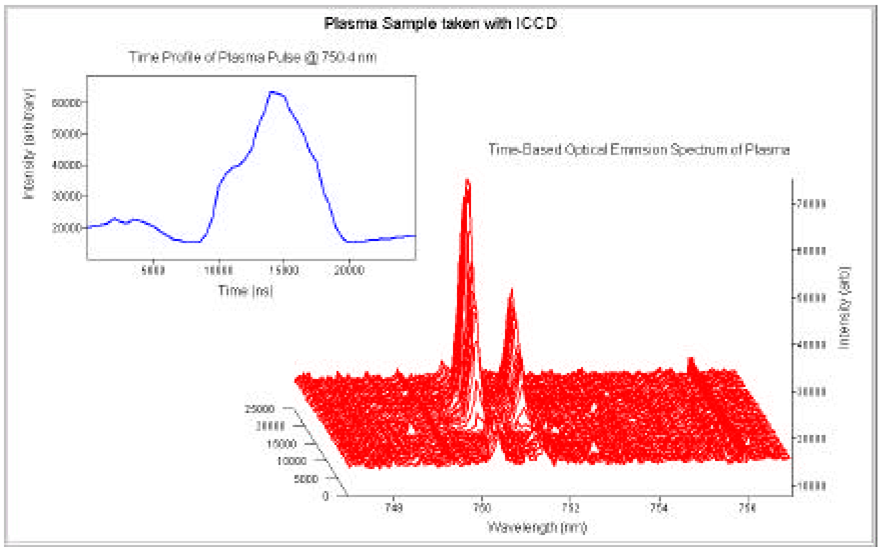
Results:

The ICCD can be used in a steady-state mode to provide Optical Emission Spectra for the plasma. This provides a picture of the various chemical species inside the deposition chamber and can be used to determine the effects of different gas mixtures and target materials. In steady-state mode the resulting spectra are the averaged emission over the full integration time of the measurement.

When operated in time gated mode, the ICCD detector system can collect the signal over a specific time period which is correlated to the time at which the plasma is triggered. The start of the plasma pulse was indicated to the system by an electronic trigger from the Plasma generator. The ICCD collects a signal at a certain time period (delay) from the trigger and collected signal only for the time slice (gate width) specified by the experiment. The signal from the same time slice was repeatedly collected over multiple pulses and the signal integrated together. The time between the start of the pulse and the data collection is automatically incremented by the software and the experiment repeated for a different time slice. All of the time slices are then combined into single dataset showing the time evolution of the optical emission spectra.



From this data, the optimum repetition rate and duty cycle of the pulsed plasma generator can be determined for different materials and allows the user to adjust and optimize the plasma discharge for better quality deposition of thin films.

Conclusion:

Using a Jobin Yvon spectroscopy system allows for the analysis and optimization of pulsed plasmas to provide higher quality deposition as well as providing a steady-state Optical Emission Spectrum measurement.

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Developed in collaboration with
Deposition Sciences Inc.,
Santa Rosa, CA:
M. George, M. Cornett.

In the USA:
Jobin Yvon Inc
3880 Park Ave,
Edison, New Jersey,
08820 USA
Tel: (732)-494-8660
Fax: (732)-549-9309
Email: OSD@jyhoriba.com

In France:
Jobin Yvon SA
16-18 rue du Canal
91165 Longjumeau cedex
France
Tel: (33) 1/64.54.13.00
Fax: (33) 1/69.09.93.19

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Germany: 89/46.23.17-0
Italy: 2/57.60.30.50
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