Chapter III

EXPERIMENTAL DETAILS OF PHOTOEMISSION OPTOGALVANIC TECHNIQUE

Introduction

Photoemission Optogalvanic (POG) technique has been used to study the fundamental processes occurring in discharge plasma [1,2,3], surface characterization of target electrodes [4,5,6], multi photon absorption [7,8,9] etc. In POG studies the basic principle is the observation of discharge plasma perturbation occurring due to the injection of photoelectrons into it. In general, the experimental aspects for observing POG effect consists of

(i) a stable electrical discharge medium with suitable target electrode,

(ii) Photoelectric emission from the target electrode using laser radiation and hence the perturbation of the discharge,

(iii) detection of the resulting POG signal.

The interaction of the photoelectron with discharge will produce an impedance change and which can be measured using appropriate detecting systems.

3.1. Discharge cell

In POG studies, a discharge cell with two electrodes filled with a desired gas at an optimum pressure is needed. One of the electrodes acts as the target electrode. A stable dc voltage is applied to the electrodes in order to sustain the discharge. A stable and low noise discharge is required for efficient measurement of POG signals. The major difficulties that arise during POG studies are due to the presence of random discharge noise as a result of fluctuations in current caused by the variations in gas pressure and/or applied voltage. The noise can be minimized by maintaining the gas pressure at a steady level and by using a highly regulated power supply.

In many POG studies commercially available hollow cathodes have also been used [4,9]. But in such cases the applications are limited, because the target electrode and the discharge gas cannot be changed.

Details of the discharge cell fabricated in our laboratory is depicted in fig.3.1. It consists of a glass tube of 1 cm diameter socketed into two metal caps made of stainless steel. Separation between the ends of the caps is 3cm and they act as electrodes. One end of the cylindrical

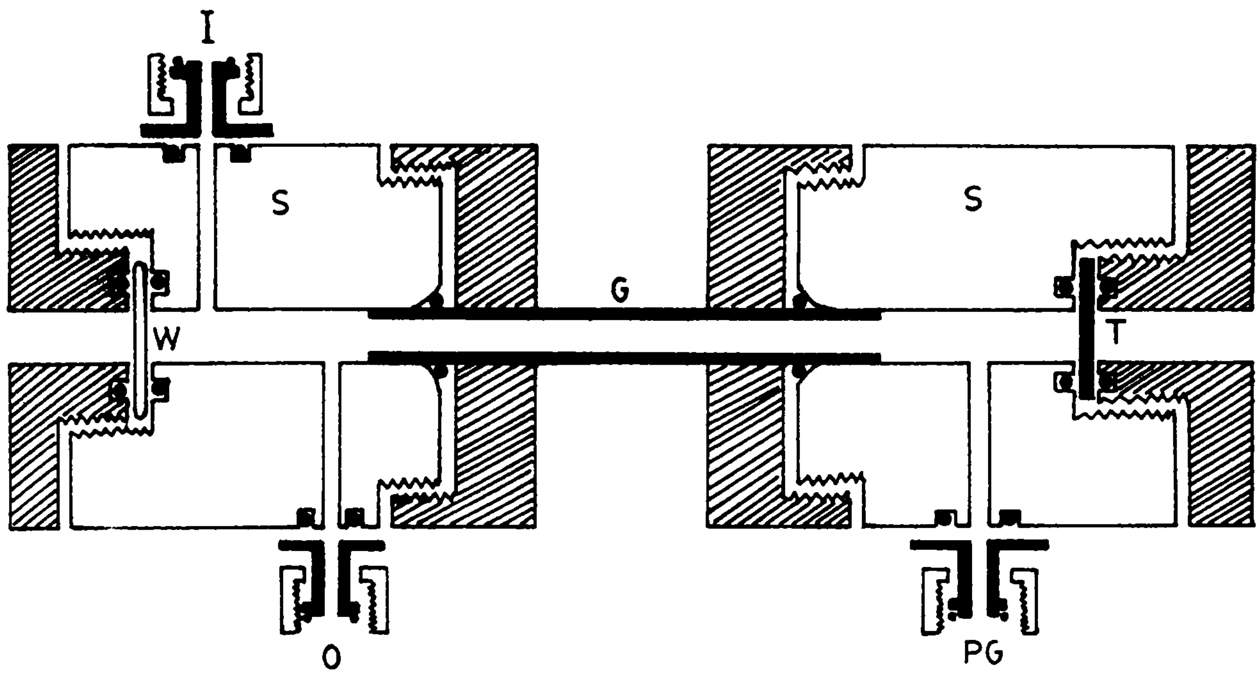

Fig. 3-1.Shematic of the discharge cell.G - glass connector, T- Target, I - gas inlet,O - gas outlet, P G - pressure gauge, S - steel caps.

cap is provided with a glass window while the desired target is fixed inside the metal cap at the other end of the discharge tube. Separation between the target and the end of the electrode is 4.5 cm. Suitable side tubes are also provided for gas inlet and outlet.

The discharge is excited using a low noise high voltage power supply (Thorn EMI PM 28 B). A ballast resistance of 66 kΩ is also included in the circuit so as to limit the current in the circuit. Discharge in the cell was maintained by using needle and diaphragm valves which are provided at the inlet and outlet sections of the cell. All the joints of the cell are vacuum tighted with `o' rings. The cleaned cell is first evacuated with a vacuum pump and then flushed by passing the discharge gas. A digital pirani gauge (Vacuum Technique Model VT DPC - 11) [Vacuum Technique Model VT DPC - 11 Instruction Manual] is used for monitoring pressure. The inlet and outlet valves are adjusted to maintain a steady gas flow so that the pressure inside the cell remains constant. A well regulated high dc voltage is applied through a ballast resistance. The discharge is then run for a long time at a slightly high current than the actual current at which the experiment is to be performed so that the presence of impurities in the cell is minimized. The discharge noise is then monitored and the pressure of the gas adjusted such that it is a minimum.

3.2. High Voltage Power Supply

One of the serious problems that limit the sensitivity in POG experiments is the presence of large discharge noise due to random fluctuations in the pressure or current. This can arise as a result of variation in gas pressure or the applied voltage,presence of impurities etc. Hence it is essential to maintain the discharge with a minimum noise using an extremely stable and ripple free voltage source. The voltage source used is a stable well regulated power supply having very low ripple factor (2 mV peak to peak) and the output controllable from 100 V to 2800 V up to a maximum of 5 mA (Thorn EMI PM 28 B) [Thorn EMI PM 28 B, High Voltage Power Supply Instruction Manual]. The unit is provided with a switch controlling the output in 200 V steps from 100 to 2800 V and a five turn potentiometer for fine voltage control giving a range of 0 to 500V

3.3. Optical Excitation System : The Nd:YAG Laser

In our experiments an Nd:YAG laser (Quanta Ray DCR - 11) [Quantay Ray DCR - 11 Nd: YAG laser Instruction Manual] was used. Nd:YAG laser is a four level laser system which has a distinct advantage over other laser systems. The properties of Nd:YAG are the most widely studied and best understood of all laser media. In normal operating conditions the wavelength selective optics limit oscillations to 1064 nm.

For a flash lamp pumped laser the pulse duration will be long, about the same as the flash lamp and its peak power will be low. A Q - switch is used to shorten the pulse and raise its peak power. The short pulse of high peak power is the key to the usefulness of the pulsed Nd:YAG laser. The present laser used for our studies has a pulse duration of 10 ns and it is used at a repetition rate of 10 Hz.

The high peak power of the Q - switched pulses permit frequency conversion in nonlinear crystals like potassium dideuterium phosphate (KDP). 1064 nm Nd:YAG fundamental interacts with the crystal to produce a secondary wave 532 nm. Both 1064 and frequency doubled 532 nm were used in the present work.

3.4. Digital Storage Oscilloscope

POG signal amplitude was measured directly from the storage oscilloscope. The storage oscilloscope used in the present work was a digital storage oscilloscope of 200 MHz frequency range (Iwatsu DS 8621,200 MHz) [Iwatsu Ds - 8621,200 MHz Instruction Manual]. This scope has the facility for signal averaging and data storing, which can also be used to obtain hard copy of signal shapes using plotter/printer.

3.5. Power Meter

For measuring the laser power/energy during various experiments the following power meters were used.

(i) Laser Power Energy Meter : (Scientech Model 362)

This is a disc calorimeter that employs calibrated thermopile which generates a voltage proportional to the heat that is liberated from the absorption of the input laser flux. Many thermoelectric junctions are arranged in series and sandwiched between an absorption surface producing heat which flows through the thermopile. The heat flow is accurately proportional to the laser beam and substantially independent of the laser beam spatial distribution of power. The thermopile output is a linear low impedance dc signal of approximately 0.09 volts/W. The following are the specifications of Scientech 362 : a flat spectral response in the region of 400 nm to 1200 nm,a continuous range from 0 to 10 watts, a maximum power density of 47 W/cm^2 and a maximum pulse energy of 3.3 J/cm^2.

(ii) Pulsed Energy Monitor : Delta Developments

This on line laser power meter uses a polarization compensated beam splitter to sample the beam, 85 % of which is transmitted through the exit face. The sampled beam strikes a retroreflecting diffuser and reaches a photodiode via a range plate which attenuates the light approximately for the range of energies being measured. All positions on the diffuser give equal signals. Different plates can be used for different energies or wavelengths. The spectral range extends from 200 nm to 1100 nm. A maximum of 300 mJ/pulse can be measured with delta development meter.

3.8. General Experimental Set-up

General scheme of the experimental set-up (fig.3.2) consists of the measurement of POG effect produced by the injection of photoelectrons into the discharge. In the present work all POG studies were carried out using N_2 as the discharge gas. Copper, Gold and Platinum were used as the target electrodes. The current limiting resistance and a milliammeter were connected in series with the cell and discharge is maintained by applying a stable dc voltage. The discharge condition is adjusted by varying applied voltage and a constant pressure is maintained to get a minimum electrical discharge noise. Pulsed radiations from Nd:YAG

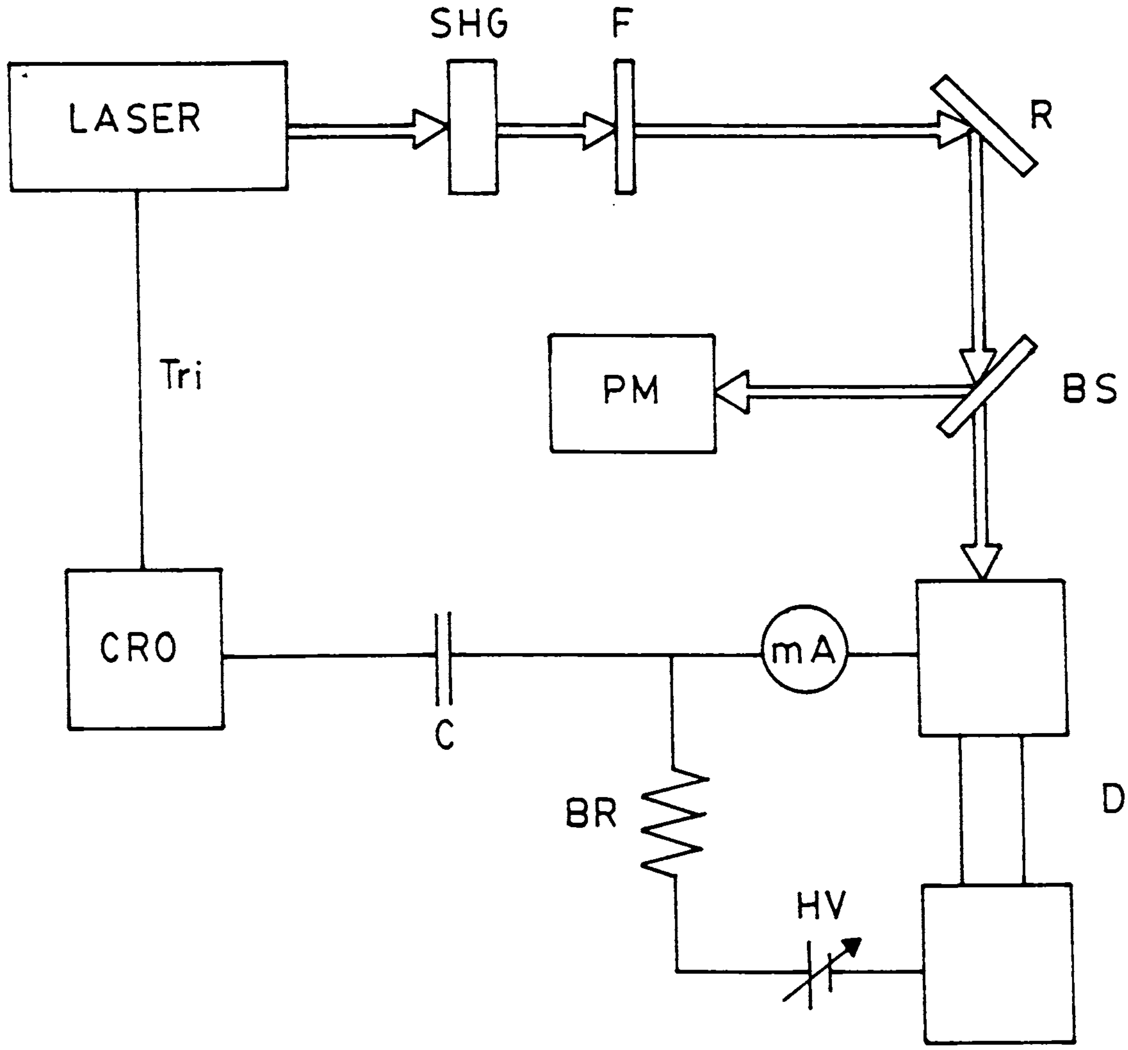

Figure 3.2 Schematic of the experimental set-up (SHG - second harmonic generator, F - harmonic separator, R - reflector, BS - beam splitter, PM - power meter, D - discharge cell, BR - ballast resistance).

laser, both 1064 nm and frequency doubled 532 nm (pulse width 10 ns and repetition rate 10Hz.) were used to excite POG signal from the targets. Signal developed across the load resistor was fed to the Digital Storage Oscilloscope through a coupling capacitor (0.1μF). The capacitor blocks the dc voltage and ac signal is measured directly from the oscilloscope.

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