L.10: Development of Compact and Versatile Hollow Cathode Lamp for Lithium Optogalvanic Studies

Hollow cathode discharge lamps are capable of generating dense plasma of magnitude one to two order higher than that of conventional planer electrodes. These lamps are widely utilized for spectroscopic studies through resonant excitation of selected transitions with a tunable laser. This report describes the development and characterization of a see through lithium hollow cathode discharge lamp for optogalvanic (OG) studies. Construction-wise the lamp is rugged, compact, versatile, and has been developed in-house at RRCAT in glass blowing facility using indigenous components.

A photograph of the Li/Ne hollow cathode (HC) lamp is shown in Fig.1. The body of the lamp is constructed from boro-silicate glass with fused silica windows mounted at the ends. Lithium (Li) is an important alkali metal required for scientific and technological activities especially in nuclear industry, therefore Li is chosen as a cathode material. Lithium is preserved in mineral oil because of its high reactivity with nitrogen and moisture. So, special care has been taken during the sample loading. Lithium foil of ~ 0.5 mm thickness is inserted into hollow cathode bore. The cathode material of the lamp can be changed easily and in less than fifteen minutes. High purity neon (99.999%) is continuously pumped typically at the flow rate of 0.02 mbar lit/sec by rotary pump through the lamp. Before applying the discharge, HC lamp is baked at 100 ^{0}C continuously for two days. The discharge is operated at low pressure (~ 5 mbar) which is controlled by a fine needle valve. Initially, the discharge observed is highly unstable. It may be due to vapors of mineral-oil and out-gassing from cathode and glass vessel. Newly prepared cathode exhibits surface scintillations for several minutes after applying the discharge. This period can be shortened by reducing the pressure temporarily below 1.0 mbar. After 4-5 hours continuous run, good and stable discharge is observed. Then lamp is operated in low current range (10-20 mA) consistent with good discharge stability and spectral line-intensity. Flow of neon gas through the lamp appears to need higher operating current to obtain the same intensity as same type of cathode in sealed lamps. This is possibly due to cooling effect of gas passing through the lamp. After extended use, waste deposit is built up on glass vessel adjacent to the cathode which causes the instability in discharge. Whenever this occurs, the lamp design has provision that it can be dismantled and the wall deposits can be cleaned by acid wash. At low pressure (< 1 mbar), the rate of deposition is observed relatively high, so it is suggested to keep the pressure typically above 1 mbar to avoid the frequent cleaning and to get long life run of the HC lamp. The warm-up time of HC lamp to achieve steady emission is around 20-25 minutes which is quite good and comparable to other similar commercial hollow cathode lamps.

Typical emission spectrum at 20 mA discharge current and 5 mbar fill-gas pressure is shown in Fig. L.10.2(a) and it is measured using spectro-photometer (Avaspec 3648-2). The recorded emission spectrum shows various emission lines of the species present in the discharge medium e.g. Li, Ne, Ne^{+}. Lithium emission line is observed at 670.78 nm ($^{2}P^{o}_{1/2,3/2} \rightarrow {}^{2}S_{1/2}$) and its intensity strongly depends upon the discharge current. The effect of fill-gas pressure on line-intensity is relatively less. Spectral lines adjacent to lithium belong to the neon gas. Emission line at 655.92 nm due to neon ions is also observed, which is possible due to good quality discharge conditions. HC lamp has been also tested for lithium and neon OG signatures (see Figs. L.10. 2b and 2c). The observed OG signals strength is good enough to be recorded directly on oscilloscope without using box-car integrator or lock-in amplifier.

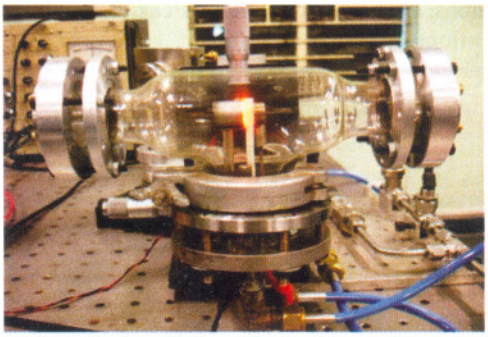

Fig. L.10.1 Photograph of Li/Ne hollow cathode lamp

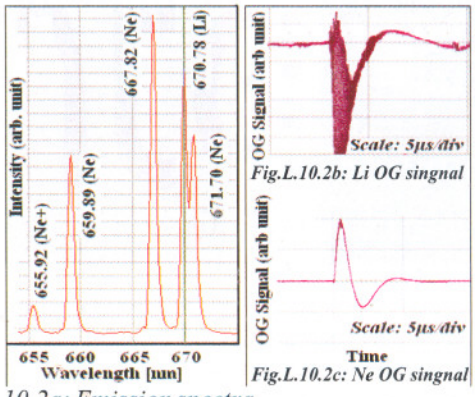

Fig.L.10.2b: Li OG singnal

Fig.L.10.2c: Ne OG singnal

Fig.L.10.2a: Emission spectra

This hollow cathode lamp has the advantage over commercially available sealed hollow cathode lamps that it can be operated at low pressure and high discharge current useful in spectroscopic studies. High current density and dense plasma make the hollow cathode discharge attractive for other applications also, such as plasma diagnostics and thin film deposition. In addition, the HC lamps are also useful for dye laser wavelength calibration and stabilization.

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