

## Research on iodine stabilized lasers in the metrology laboratory of Eindhoven University of Technology

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RESEARCH ON IODINE STABILIZED LASERS IN THE  
METROLOGY LABORATORY OF EINDHOVEN UNIVERSITY  
OF TECHNOLOGY.

P. SCHELLEKENS

WT Rapport Nr. 0 384

Dit rapport is geschreven voor onderzoekers werkzaam op het gebied van golflengtestabilisatie van He-Ne lasers. Het rapport is de schriftelijke weergave van een voordracht door de auteur gehouden te Braunschweig op 11 februari 1977.

Het geheel wordt in deze vorm gepubliceerd in het blad P.T.B.-Berichten, een uitgave van de Physikalisch-Technische Bundesanstalt te Braunschweig, West-Duitsland.

RESEARCH ON IODINE STABILIZED LASERS IN THE  
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P. SCHELLEKENS

SUMMARY

This report consists of four parts. The first is a short description of our iodine stabilized lasers. Next we have given a description of our manufacturing process for making plasm tubes and a method for determining optimum filling pressure and discharge current. Finally, the results are summarized.

A. WORK ON IODINE LASERS

Research on iodine stabilized lasers has started in 1974 as we felt a need for a more stable laser than the Spectra-Physics 119 available. The latter is used as a light source in our line standard interferometer and limits its accuracy. Our plan was to build a small compact light source which was easily transportable. From the beginning we tried to build our own plasm tubes as well as the iodine cells. For this part there was an extremely good cooperation between our laboratory and the technical service department (CTD, THE)\*).

In principle our lasers consist of a mechanical structure of steel in which Zerodur bars are mounted. On these bars the mirror adjustment plates are supported in such a way that the length of the cavity is determined solely by the Zerodur bars (Fig. 1). Even if no external stabilization system is used this results in a good frequency stability.

The plasm tube is of the so called side-arm type. It is entirely home made, has a long life time and a noise level comparable with commercial tubes.

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\*) Section Glasstechnology: J.C. Hendriks.

Section Optics: J.W. Versteeg.

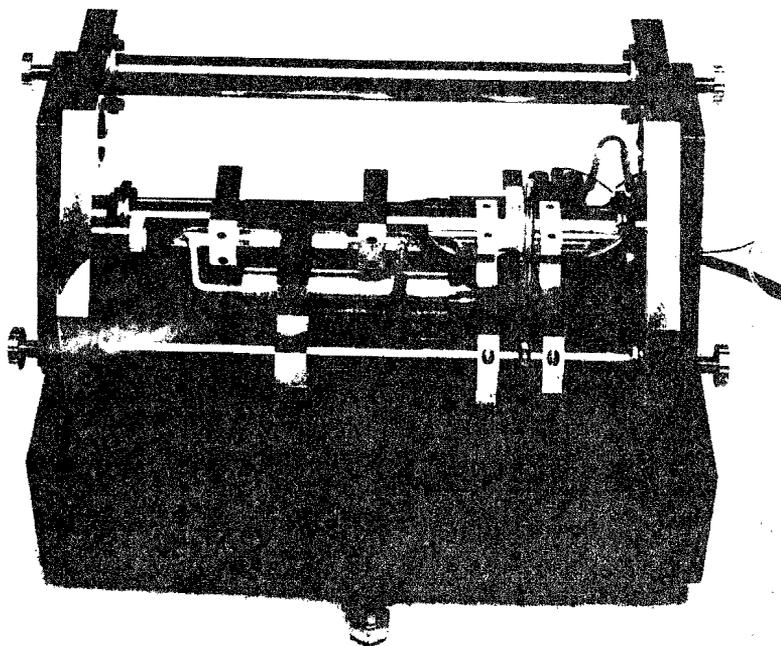


Fig. 1.

Quartz is used as material for the iodine cells because the windows are fused on with "glass transfer tape" [1,2]. We cannot recommend this method for sealing windows onto plasm tubes as the danger of contamination of the small windows is too high. Until now we have used piezo-electric cylinders supplied by Jodon (MD-44), the lasermirrors are supplied by Spectra-Physics. Maximum output power is around 300  $\mu$ W using a plasm tube with 135 mm gain length and a 100 mm absorption cell, total mirror distance is 230 mm. The electronic circuit is based on the third derivative method [3]. We are using commercial P.S.D.'s (PAR) with home made oscillators supplying  $f$  and  $3f$ . In April 1976 a comparison was made between NPL and THE lasers. Using Wallard's integrators we have measured a stability of  $2 \times 10^{-11}$  for 10 sec averaging time. Reproducibility seems better than  $1 \times 10^{-10}$ . At this moment we are working on improved electronics and another mechanical structure. By this means we hope to improve stability and reproducibility. We have planned new intercomparisons in the second half of this year.

#### B. PRODUCTION OF PLASMATUBES

During the recent meeting at PTB many people seemed interested in the process of making plasm tubes. So it may be useful to describe our methods here. Further we think it is advisable to

use not only commercially available plasm tubes in experiments with iodine stabilized lasers.

At this moment we are only making side-arm tubes as we have very good results with them.

The plasm tubes consists of a capillary part and a cathode part, both made of pyrex. Side-arms are fused on the capillary part, the planes for the brewster windows are made by a sawing process and afterwards roughly polished.

The cathode part has a diameter of 25 mm and a length of around 130 mm. The cathode is turned from pure aluminium (99,9%) using a diamond cutting tool and a continuous flow of water around the cutting tool. In this way a good oxide layer is formed on the surface which is very resistant against sputtering. The anode pin and the cathode support pin are made of tungsten which is heated to 1000 °C before sealing in. The connection between cathode support pin and cathode is made by a nickel wire on which a barium getter is mounted.

Before fusing together the glass parts are cleaned by usual techniques and dried in a dustfree oven. After the fusing process the plasm tube, still without brewster windows, is placed in a tube-oven and heated to 400 °C for 5-10 hours under rough vacuum ( $10^{-3}$  Pa). The next step is to mount the windows. The brewster windows are made of fused silica with a thickness of 2 mm. Generally the window is polished before use. After cleaning carefully the windows can be mounted on the plasm tube. Since we are using a low viscosity cement we have to clamp the windows onto the plasm tube (Fig. 2).

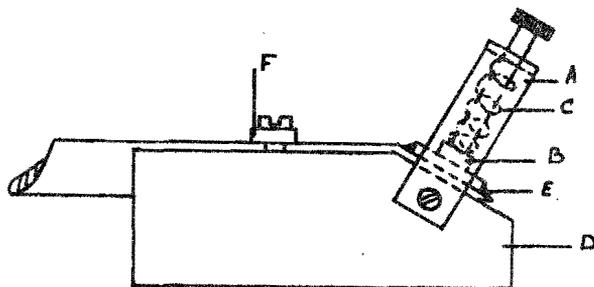


Fig. 2.

- A: Rotatable holder
- B: Pressure pen for brewster windows
- C: Spring
- D: Plasm tube holder
- E: Cement
- F: Clamp screw plasm tube

We have experienced good results with a two component cement called APCO-313<sup>\*</sup>). This cement remains elastic and therefore it seems to be better than Torr-Seal which cracks easily. After putting on the cement the plasmatube is put in an oven at 80 °C for a few hours. Then the filling procedure can be started. The pumping system consists of a forepump and a high-vacuumpump and is connected with the filling station onto which the plasmatube has been fused.

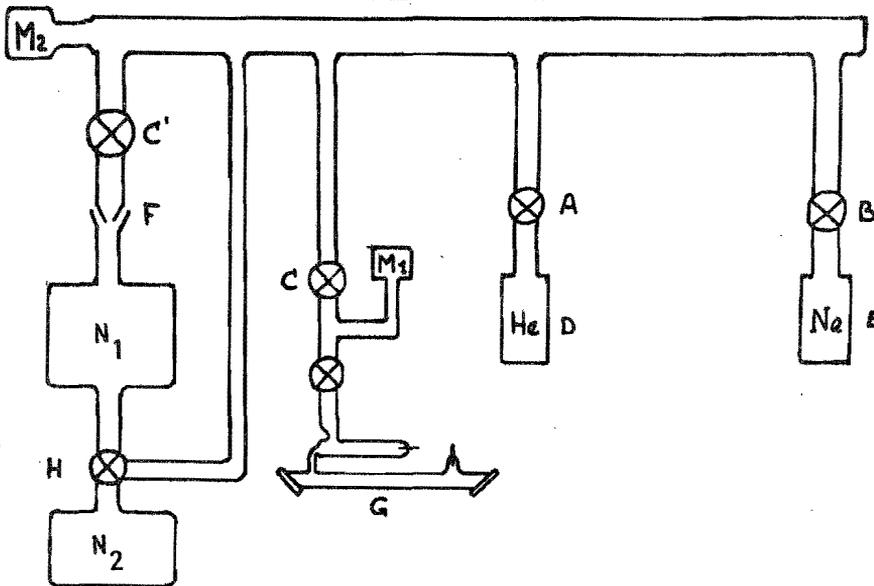


Fig. 3.

- A, B : Filling taps
- C, C', H: Headtaps
- D, E : Supply He, Ne
- F : Liquid nitrogen trap
- G : Plasmatube
- O : Teflon taps
- M<sub>1</sub>, M<sub>2</sub> : Manometers
- N<sub>1</sub>, N<sub>2</sub> : Vacuum-pumps

Fig. 3. gives a schematic diagram of the setup. After the tube is pumped to  $10^{-5}$  Pa,  $^{20}\text{Ne}$  is filled in to the required partial pressure and then this is repeated with  $^3\text{He}$ . Then a discharge is started and run for one hour. If there are leaks the discharge will turn to a blue colour. Next the tube is pumped vacuum again and refilled to a total overpressure of 100 Pa and the discharge is run for 48 hours so that diffusion processes can come to an equilibrium (burning-in process). The last step consists of vacuum pumping, evaporation of getter material and refilling with  $^3\text{He} : ^{20}\text{Ne} = 7 : 1$  to the total pressure calculated from  $pD = 400$  Pa.mm. The pressures are measured by a pirani gauge, using calibration curves for the gasses used. If, after starting the discharge, the colour is rose-red the plasmatube is sealed off.

<sup>\*</sup>) APCO R 313 delivered by: Applied Plastics Co. Inc.  
612 E. Franklin Avenue, El Segundo, California 90245.

C. DETERMINATION OF OPTIMUM FILLING PRESSURE AND DISCHARGE CURRENT IN A He-Ne PLASMATUBE

To carry out this experiment we have mounted a cavity around the plasmatube while it was connected to the filling station. Within this cavity a rotatable glassplate was mounted so we could introduce variable losses. If oscillation just stops gain equals total losses

or:  $G_m = a_t + l(\phi_m)$  (a)

where  $G_m$  = roundtrip gain  
 $a_t$  = roundtrip losses (scattering + transmission)  
 $l(\phi_m)$  = loss introduced by rotatable glassplate  
 $l(\phi_m)$  can be calculated from: [4]

$$l(\phi) = 1 - \left[ \frac{(1-R)^2}{1-R^2} \right]^2 \quad (b)$$

where (from Fresnell's equations):

$$R = \frac{\tan^2 \left( \phi - \arcsin \left( \frac{\sin \phi}{n} \right) \right)}{\tan^2 \left( \phi + \arcsin \left( \frac{\sin \phi}{n} \right) \right)} \quad (c)$$

with:  $n$  = index of refraction of glassplate.  
 $\phi$  = the smallest angle between the normal on the glassplate and the laserbeam direction.

Fig. 4 gives a schematic diagram of the experiment. By filling the plasmatube to various partial and total pressures and measuring  $\phi_m$  at different discharge currents the gain can be determined as a function of pressure and discharge current and optimum filling pressure can be read from a graph. From power measurements with  $\phi \neq \phi_m$  we have calculated the saturation parameter  $W_0$  [5].

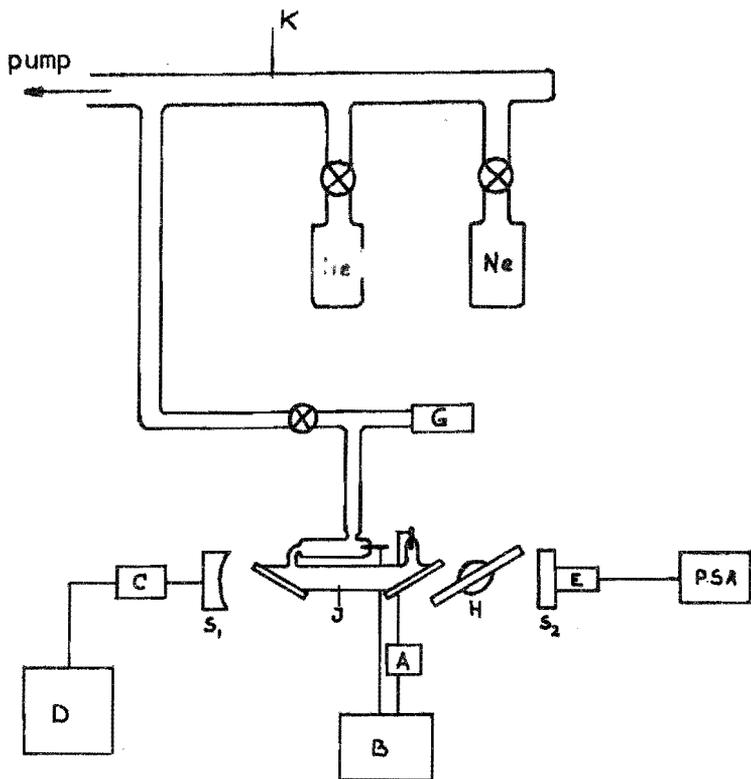


Fig. 4.

- A : Ammeter
- B : Power supply
- C : Detector
- D : Power meter
- E : Piezo-cylinder
- S<sub>1</sub>, S<sub>2</sub> : Laser-mirrors
- G : Manometer
- H : Rotatable glassplate
- J : Plasmatube
- PSA : DC supply

Smith [6] gives a roundtrip gain for  $\lambda = 0,6 \mu\text{m}$ :

$$G_m = \frac{g'_0 \times L}{D}$$

with: L : roundtrip gainlength  
 D : internal plasmatubediameter  
 $g'_0 : 3,0 \times 10^{-2} (\%)$

Fig. 5 shows some of our measurements with a 7 : 1 mixture of <sup>3</sup>He and <sup>20</sup>Ne, a plasmatubediameter of 1,20 mm and a gainlength of 135 mm. Maximum gain is reached around 400 Pa mm.

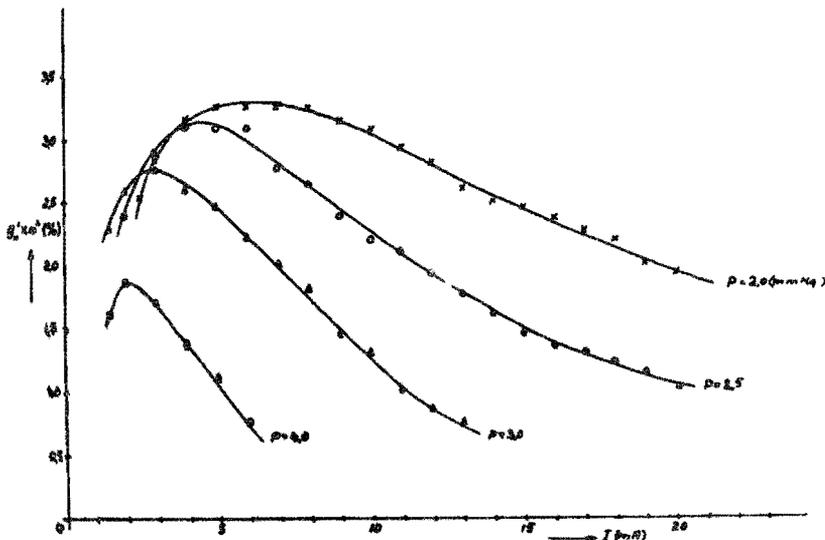


Fig. 5.

We have calculated a value of  $W_0$  of

$$W_0 = (28 \pm 3) \text{ W cm}^{-2}$$

which is in good agreement with the value given in [5].

#### D. FINAL REMARKS

The results of our experiments with homemade plasm tubes shows good agreement with other experiments published and the power measurements give results comparable with commercial lasers [2]. We think we can conclude that the methods described in part B results in a plasm tube suitable for iodine and methane stabilized lasers. The experiments were carried out by only a few people and the necessary instrumentation and apparatus was neither very expensive nor complicated.

#### REFERENCES

- [1] R.A.L. Mason  
Journal of Physics E 1976, vol. 9, 816-817.
- [2] P. Schellekens, J.W. Versteeg  
THE (not published).
- [3] A. Wallard  
Journal of Physics E 1972, vol. 5, 927.
- [4] B. Patel, S. Charan, A. Mallik and P. Swarup  
Journal of Physics D 1974, vol. 7, L40-L44.
- [5] D.C. Sinclair and W.E. Bell  
Gaslasertechnology 1969.
- [6] P.W. Smith  
Journal of Quantum Electronics 1966, vol. QE-2, No. 4,  
77-79.