BUREAU INTERNATIONAL DES POIDS ET MESURES

Report on the first meeting of the group on Laser Diode Heads 17-18 April 1997

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December 1998
Pavillon de Breteuil, F-92312 SEVRES Cedex

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Introduction

For about ten years, laser diodes (LDs) have commonly been used for metrological purposes. Only recently however have wavelength LDs below 650 nm become available. Every time that a junction compound is pushed to the limit of its emission, the crystal experiences high strain leading to a shorter lifetime. There is little we can do about this physical strain but we may decrease it by reducing the temperature or the current passing through the diode.

Those who work on LDs know that many precautions have to be taken when using them, especially when making contact or switching the LD on or off. Electronic protections may reduce the danger. Optical destruction of the cleaved facets is another important problem in working with LDs, especially, LDs with anti-reflection coatings (AR) which have to be carefully preserved from dust and other mechanical contacts.

To characterised the systems for possible new recommended standard, we have to study as many phenomena as possible. That is why a mobile unit containing at least the LD should allow us to carry out the following operations:

- check the diode relative to the initial curves of operation
- test the diode in an other ECL
- change easily the diode during a comparison with a minimal disturbance of the measurement system. (optical bench, laser unit mechanic, other lasers...)

The principal task of the group is to proposed a structure for a Laser Diode Head (LDH) which combines good protection for the laser diode with ease of use. The following points were considered (not limited) :

- temperature control
- current limitation
- pulses reduction or elimination
- mechanical protection

Already available were:

- mechanical design and materials
- range of the system

Invited members

The meeting was organized by A. Zarka and J.M Chartier of the BIPM.

The following were invited :

● Belgium,	AIM	Hugo Pirée
● Denmark,	DFM	Harald Simonsen
● England	NPL	Cristopher Edwards
●Germany	PTB	Ahmed Abou-Zeid
		Frank Imkenberg
●France	ETCA	Patrick Bourdon

Last minute difficulties made it impossible for the AIM, NPL and ETCA to attend this session.

Laser heads presented during the meeting

One of the major interests of this meeting was to compare the mechanical designs used in the different laboratories. Seven different lasers or laser heads were presented.

DFM ECL based on Littman configuration

The complete DFM extended cavity laser (ECL) is shown on Figure 1. The Littman configuration is used with a ruled diffraction grating (1200 l/mm, 750 nm blaze). The mechanical parts are glued to a zerodur plate. The lens is mounted on an XY translation stage and the focus is obtained using a rotating movement.

In the upper right corner one can easily see the electronic protection of the type described in [1]

The laser head (Thorlabs LM9F/M), is glued to a 10 mm x 10 mm Peltier element and the temperature sensor is of type AD590. The laser diode used is a 15 mW index-guided device (SDL-7501-G1), on which the front facet has been anti-reflection coated. The cavity length is 16 cm.

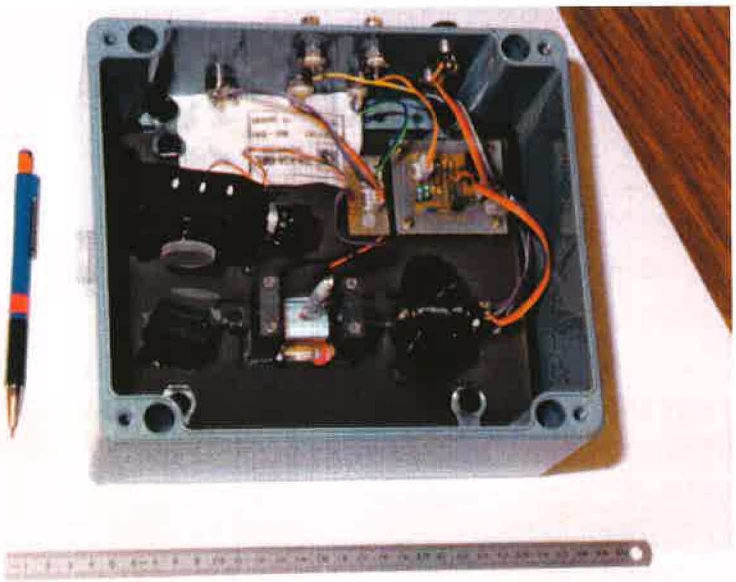


Figure 1 : DFM ECL Littman configuration with an internal iodine cell

PTB laser heads

The PTB brought three laser heads of which two were made in its laboratories (Figure 2).
The first (right) is used with the LD locked on the linear absorption of iodine. The second (centre) is a new LDH (not yet tested) of small size (20 mm x 20 mm x16 mm). These dimensions are about the smallest which it is reasonable to mount, to regulate and to fix the components.

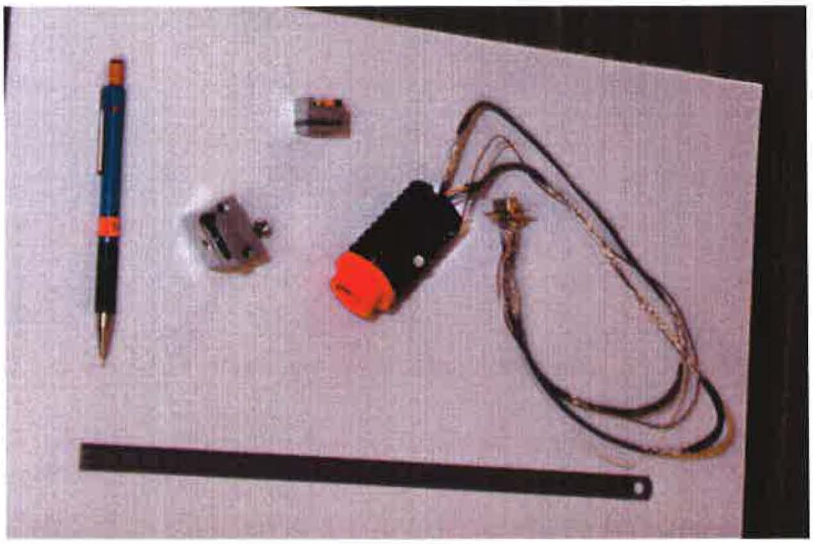


Figure 2: PTB laser heads

The third (left) is a model sold from Dr Sacher which is used either in a Littman or a Littrow cavity.

BIPM ECL based on a Littrow configuration

The BIPM ECL is based on a Littrow configuration. Its particularity is the use of a LD with a micro-lens (by Blue-Sky). It was the first to be used in intracavity configuration system.
Figure 3 shows the BIREL1-2 laser. The lens is mounted on an XY translation stage and a rotating system is used to make the collimating. On the BIREL1-1 laser (previously named Birel1), the movement was made with a more convenient translation table.

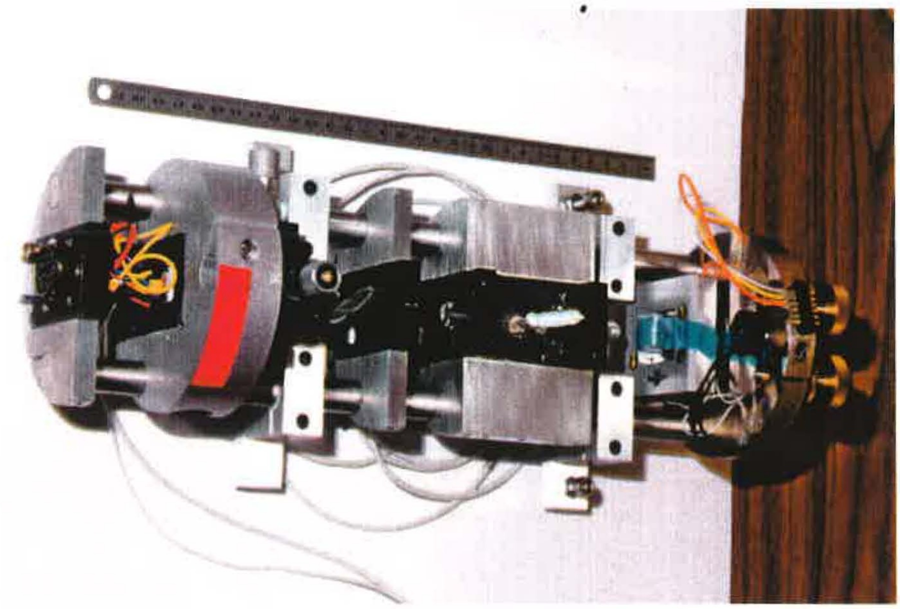
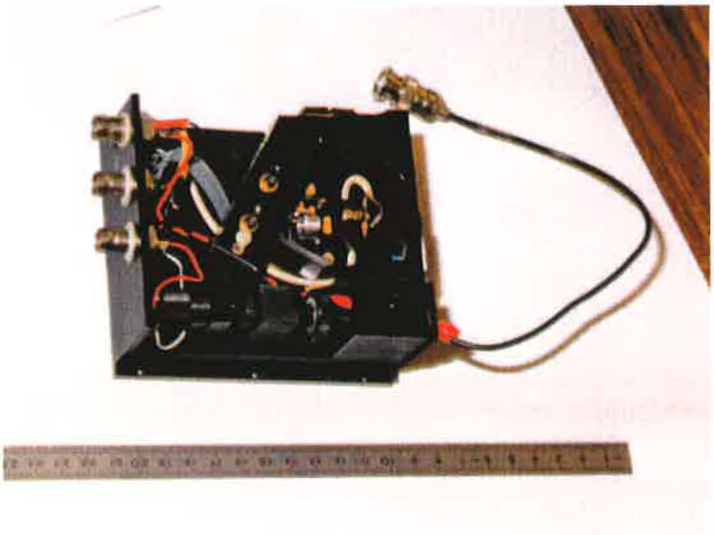


Figure 3: BIPM ECL (BIREL 1-2) in Littrow configuration with internal iodine cell.

The temperature of the junction is set to within 0.01°C (but the stability is better). The thermal sensor is a pearl thermistor (30kΩ at 25°C). The LDH, made in copper, is held between two Peltier elements to limit the thermal expansion of the cavity.

The second prototype system based on plates seems less stable than BIREL1 series, but the mechanical design was not yet completely defined (grating movement has to be improved).

The last mechanical design presented (Figure 4) was by Dr de la Bachelerie and has operating for the past four years at $\lambda \approx 780$ nm. The lens is glued, the thermal sensor is a 10kΩ thermistor.



Picture 4 : Dr de la Bachelerie LD design using Littrow configuration.

Diode protection

Electrostatic protection

One of the most critical conditions limiting the lifetime of a LD is the need to operate with as small electromagnetic and current pulses. Some of the rules to observe are as follows:

- use a shielded cable for the current source
- mount the LD in a properly shielded area
- use a slow up/down power supply.

Another rule is to connect the diode as close as possible to a protection mounting as described in [1]. The PTB and DFM already use such systems.

The electronic board should be placed as close as possible to the diode. If possible, it should be shielded and equipped with a connector to simplify change.

Thermal protection

Control of the junction temperature is critical for the operation of uncoated LDs. This is why a double servo-loop is recommended for temperature control. Great care must be taken to avoid degradation of the LD.

● for excessive low temperatures (around 10°C in normal conditions) water may condense on the faces of the LD.

● for excessive high temperatures (around 30°C) the life time of the diode is greatly reduced (by a amount of 2). For this reason a temperature range of 10°C-30°C with 1 mK stability is required for the junction temperature to stabilize the laser head.

For the long term stability, and to reduce the amplitude of the correction applied on the Piezo transducer (PZT) controlling the ECL, the whole laser should be stabilized to better than 0.1 °K.

If the Peltier element current is greater than 1 A , special care should be taken to avoid electromagnetic effect (EMC) on the LD.

The thermal sensor should be of type AD590 to allow the exchange of temperature control systems, but the configuration should be such that a static or a removable sensor may be used.

Mechanical protection

Laser diodes equipped with an anti-reflection coating are especially fragile. For this reason the mechanical casing should protect against dust and finger contact on the face. The diode must be supported firmly to avoid noise due to mechanical vibrations.

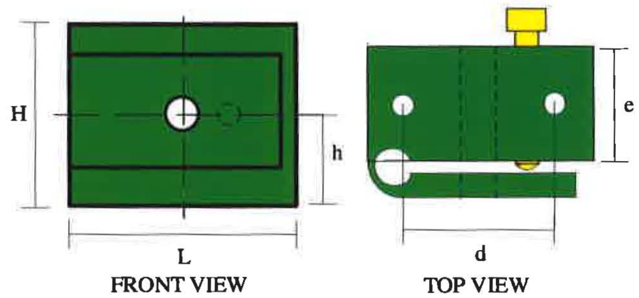


Figure5 : Typical laser head design

After comparing the different lasers and heads the group conclude that a laser head with a mechanical design similar to that used by Dr Sacher is the best. It advantages includes:

- LD protection
- stability
- size
- price
- ease of temperature regulation
- ease of collimation

The indicated dimensions are (mm):

$H = 24$ $h = 12$ $L = 30$

$d = 20$ $e = 15$

The distance between the main body and the arm is function (4 mm to 10 mm)of the focal lens

A useful design modification should be to add a protective cover to the lens in the case this is longer than the width of the arm.

Aluminium is a suitable construction material since it provide good thermal conduction, low weight and the possibility of anodization.

The mounting point is from the top to allow the dismounting. Twenty mm between the screws enables large Peltier element. It would be helpful to make one mounting point in the form of a slit to provide an additional degree of freedom for azimuthal tuning without lost of stability.

Diodes types

The PTB has published an interesting paper [2] concerning diodes for the use near 633 nm. The SDL model 7501G is the most suitable for this wavelength.

The only case currently in use is the TO9. The tolerance on its dimensions should be close enough to allow repeatability in the positioning of the diode inside the laser head.

Both AR and uncoated diodes are available, but for diodes equipped with a micro-lens, the distance of the arm may be different.

The observed tuning ranges obtained with SDL7501G LDs are as follows:

LABORATORY	micro-lens	anti-reflection	tunability /nm
PTB	-	-	± 2
BIPM	X	-	± 4
DFM	X	-	± 3.5
DFM	-	X	± 10
PTB	-	X	± 16

Conclusion

This meeting has showed that national laboratory specialists are very interested in finding ways to improve the use of LDs in metrology with the objective of defining new reliable standards based on laser diodes. It is certain that the next meeting will attend more participants.

The diversity of lasers exhibited shows that comparable results may be obtained using different configurations (Littman, Littrow) and different LD types (micro-lens, CAR, normal). The choices to be made depend mainly on size, the weights and the ease of use.

If more care were brought to the realization of its mechanical design it should be possible to construct a more suitable ECL and also to improve its rigidity.

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