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TECHNICAL REPORT

Fibre optic active components and devices – Reliability standards – Part 2: Laser module degradation

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CONTENTS

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FIBRE OPTIC ACTIVE COMPONENTS AND DEVICES – RELIABILITY STANDARDS –

Part 2: Laser module degradation

FOREWORD

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IEC 61751-2, which is a technical report, has been prepared by subcommittee 86C: Fibre optic systems and active devices of IEC technical committee 86: Fibre optics, based on the Standard IEC 61751 prepared by subcommittee 47C: Optoelectronic, display and imaging devices, of IEC technical committee 47: Semiconductor devices.

The field of this technical report will henceforth be placed under the responsibility of IEC technical committee 86: Fibre optics.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
86C/833/DTR	86C/847/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of IEC 62752 series, under the general title *Fibre optic active components and devices – Reliability standards*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

The laser modules covered by this technical report are purchased by a system supplier (SS) to be inserted in equipments which in turn are supplied/sold to a system operator (SO), for example, a telecommunications company (see definitions in Clause 3).

For the system operator to act as an informed buyer, knowledge of the potential risks posed by the use of critical components is required.

Optoelectronic component technology is continuing to develop. Consequently, during product development phases, many failure mechanisms in laser modules have been identified. These failure mechanisms, if undetected, could result in very short laser lifetime in system use.

FIBRE OPTIC ACTIVE COMPONENTS AND DEVICES – RELIABILITY STANDARDS –

Part 2: Laser module degradation

1 Scope

This technical report deals with reliability assessment of laser modules used for telecommunication guidance on testing, use of failure criteria and reliability predictions is provided.

This technical report provides guidance on:

– the testing that a system supplier should ensure is in a place prior to procurement of a laser module from a laser module manufacturer;

– a range of activities expected of a system supplier to verify a laser module manufacturer's reliability claims.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-2-1: *Environmental testing – Part 2-1: Tests. Tests A: Cold*

IEC 60068-2-14: *Environmental testing – Part 2-14: Tests. Test N: Change of temperature*

IEC 60747-1: *Semiconductor devices Part 1: General*

IEC 60749-1: *Semiconductor devices – Mechanical and climatic test methods Part 1: General*

ISO 9000: *Quality management systems – Fundamentals and vocabulary*

MIL-STD-883G: *Test method standard, microcircuits*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
laser module
packaged assembly containing a laser diode with/without photodiode

NOTE The module may also include a cooler and temperature sensor to enable laser temperature to be controlled and monitored. The optical output is normally via an optical fibre pigtail.

3.2
submount
substrate upon which a laser is mounted for assembly into the subcarrier

3.3
subcarrier
substrate upon which a laser diode and/or photodiode may be mounted for assembly into the laser module

NOTE Components on submounts are also subject to qualification testing.

3.4
laser module manufacturer (LMM)
manufacturer of laser modules who provides devices meeting the requirements of the relevant detail specification (DS) and the customer's reliability requirements

3.5
system supplier (SS)
manufacturer of telecommunications/data transmission equipment containing optoelectronic semiconductor lasers, i.e. laser module customer

3.6
system operator (SO)
network operator of telecommunications/data transmission equipment containing optoelectronic semiconductor lasers in the transmission path

NOTE The system may also be part of other more extensive systems, for example telecommunications, rail, road vehicles, aerospace or weapons.

3.7
capability qualifying components (CQC)
components selected to represent critical stages of the process and limiting or boundary characteristics of mechanical and electro-optic design.

4 Laser diode and laser module failure mechanisms

4.1 General

Much of the published laser reliability data (and also reliability data from laser manufacturers) is from the service life testing of laser chips bonded onto submounts or special headers. The results usually show increasing threshold or operating currents leading to eventual failure. However, other laser characteristics can also degrade and should be monitored during life testing, for example, light-output spectrum.

Practical laser transmitters, as used in fibre transmission systems, contain several other important piece parts and components that are also vulnerable to failure. For example, reduced fibre output power, due to instability in the fibre to laser chip alignment, is a significant failure mechanism in laser modules. Less information is available on the stability of the output from receptacle packages.

Various kinds of laser module have been used in fibre transmission systems. An example structure for laser module is shown in Figure 1 in which the laser chip is mounted on a submount within a dual-in-line package with a fibre pigtail. The temperature of the laser submount is often controlled using a TEC, with a thermistor as a temperature sensor. Some distributed feedback laser modules for use in high bit-rate optical fibre systems also contain optical isolators to prevent reflected optical power from adversely affecting the laser operation. Advanced modules containing integrated circuits for some control functions are also available.

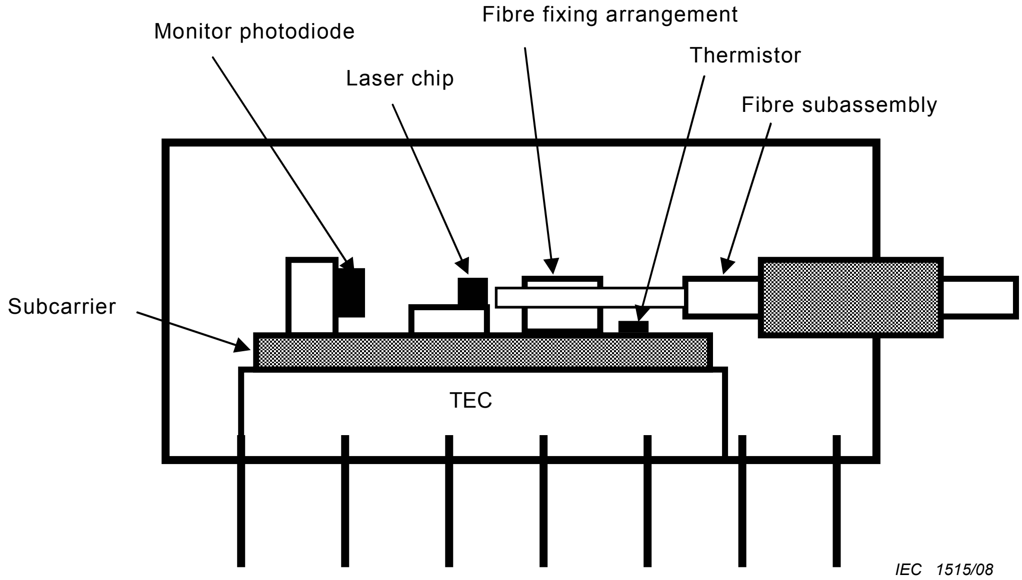

Figure 1 – An example of cross-section for laser module

4.2 Description of the main failure mechanisms which affect laser diodes and laser modules

4.2.1 Laser diodes

Two typical cross-sections through a ridge waveguide and a buried heterostructure type InGaAsP/InP laser are shown in Figure 2. A wide range of failure mechanisms has been identified in laser diodes associated with material defects in the semiconductor material, facet degradation, both p and n-side metallizations and with the bond to the heatsink. These failure mechanisms are discussed in more detail below.

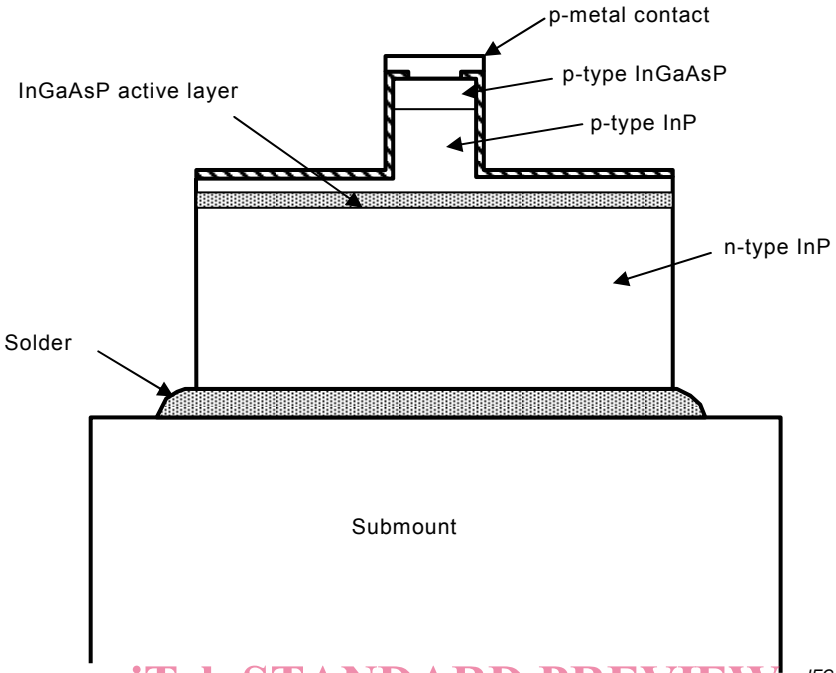

Figure 2a – Ridge waveguide type

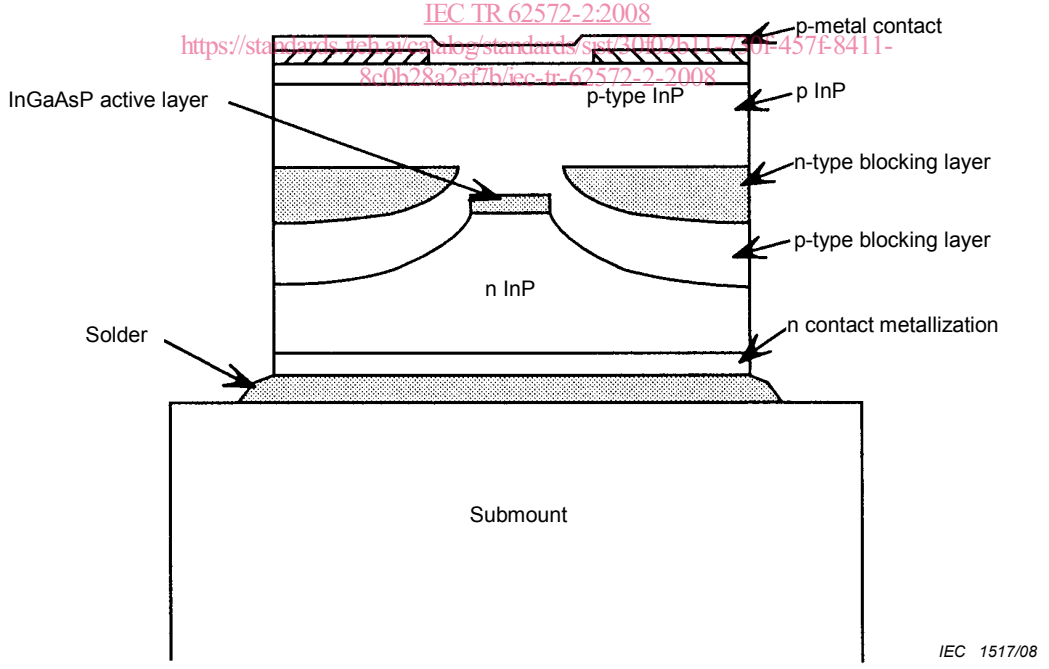

Figure 2b – Buried heterostructure type

Figure 2 – Cross-section through a typical heterostructure laser (bonded section side up)

a) Degradation due to the growth of material defects