RUGGED OPTICAL SUBMODULES FOR MICROWAVE APPLICATIONS

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ABSTRACT

A new concept of microwave opto-electronic modules is presented. Those modules (laser transmitter and photodiode receiver) can either be used directly in any hybrid design of a microwave system involving optoelectronics or more conventionally fitted into a proper package. They are well suited for all the applications requiring stringent environmental conditions such as military or space.

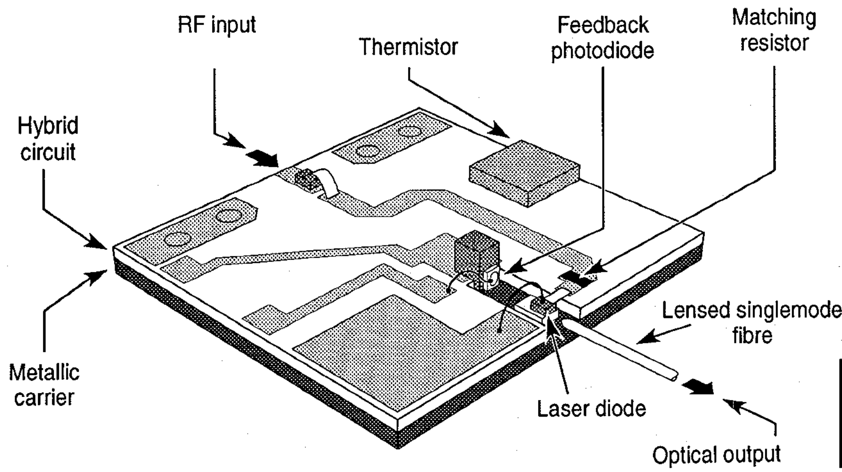

Figure 1

INTRODUCTION

Because of the many advantages of optical fibres: huge bandwidth, low losses, small size, low weight,... there has been a growing interest in high speed (digital and analog) optical links. Transmitters and receivers for such links are now available up to Ku band. However, those modules are not very practical for high integration. We have addressed this issue by designing a new kind of optical submodules directly suitable for hybrid integration.

TRANSMITTER SUBMODULE

The transmitter is build around a semiconductor laser which can be of different types: Fabry-Perot or DFB, conductive or semi-insulating substrate, output wavelength of 1.3μm or 1.5μm. It is mounted on a diamond heatsink with the epitaxial layers down for a better thermal dissipation. This subassembly is brazed on a metallic carrier (see Figure 1) or corner plate (see Figure 2) to which an hybrid circuit is also attached. A feedback photodiode which is tilted to avoid back-reflection into the laser, and a thermistor to monitor the temperature of the chip are both fixed onto the circuit which is usually made of alumina, The laser is connected to the RF signal through a 50Ω microstrip line and a matching resistor for wide band operation. The latter can be replaced by a reactive matching circuit for narrow band operation which reduces the losses of the electrical to optical conversion.

A critical factor in this conversion is the coupling efficiency between the laser and the fibre. A lens at the end of the fibre provides a good coupling coefficient but at the expenses of the tolerances on the position of the fibre: a 1dB loss corresponds to an axial misalignment of roughly 1μm. So the fibre has to be carefully positioned and fixed to avoid any variation in the coupling ratio and hence in the insertion losses. This is all the more difficult in harsh environments often found in military or space applications. In order to obtain a good stability a patented YAG welding technique has been developed. The lensed fibre is attached into a fibre carrier which slides on the corner plate (see Figure 2). The carrier is dynamically moved to obtain the optimum position and then welded. The resulting coupling efficiency is equal to or greater than 50%.

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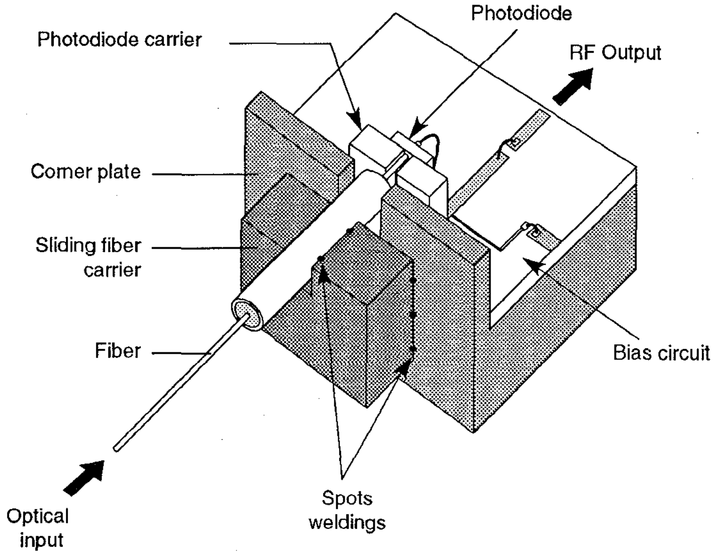


Figure 2

This technique has been validated by submitting the submodule to the following tests without any degradation of the coupling ratio:

- more than 100 thermal one hour cycles consisting of 30 minutes at -50oC and +125oC respectively
- 100g shocks during 6ms
- 10g vibrations between 10Hz and 2kHz
- 200g accelerations during 10s

Figure 3 shows the S_{21} of such a module. The 3dB bandwidth, which is around 19GHz is only limited by the laser. If necessary, the same submodule can be included in a small package which contains a military class thermo-cooler and provides a connectorized input. Tightness is classically obtained with glass beads for the RF and electrical inputs/outputs and silica/glass/metal feedthrough for the fibre pigtail while the cover is YAG welded in an atmosphere of nitrogen or argon.

RECEIVER SUBMODULE

Basically, the method used for the receiver submodule is the same as for the transmitter. The photodiode is a back illuminated InP/InGaAs/InGaAsP PIN diode with an anti-reflection coating. It is mounted on a ceramic microcarrier (see Figure 2) which, in turn, is assembled onto an hybrid circuit consisting in a bias circuit and an RF output for the photodiode. Again, this assembly is attached to a corner plate (or metallic carrier) and the coupling is realized the same way as for the laser. The only difference is that the end of the fibre does not have a lens but is cleaved at an angle to avoid back-reflections into the fibre giving a figure lower than 10^{-4} for the receiver. The coupling efficiency between the fibre and the photodiode is better than 90% and again shows no degradation during the temperature tests because of the nearly identical coupling scheme used.

Figure 4 shows the S_{21} of such a module. The 3dB bandwidth, which is around 17GHz is only limited by the photodiode. If necessary, the same submodule can be included in a connectorized small package. Again the cover is sealed under an atmosphere of nitrogen or argon with a YAG laser while two glass beads and a silica/glass/metal feedthrough provide the necessary tightness for the bias input, the RF output and the fibre pigtail respectively.

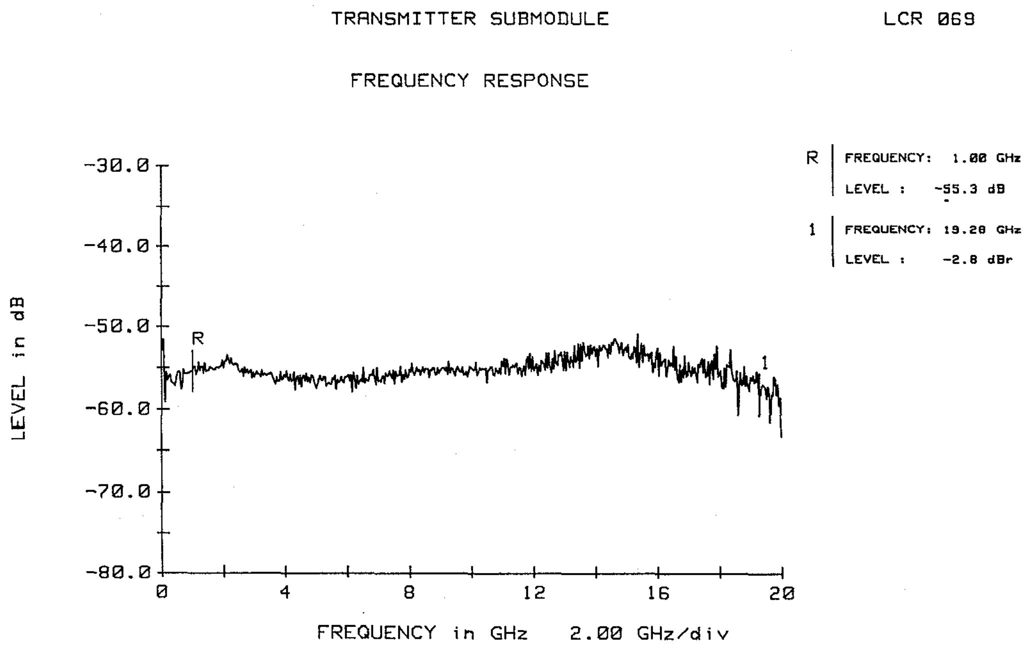


Figure 3

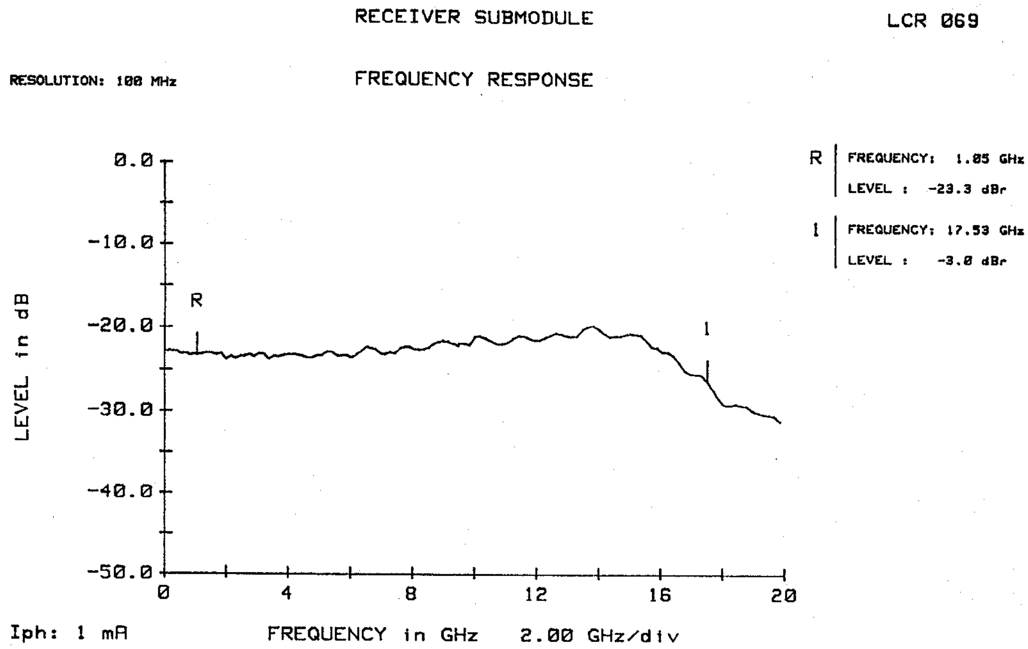
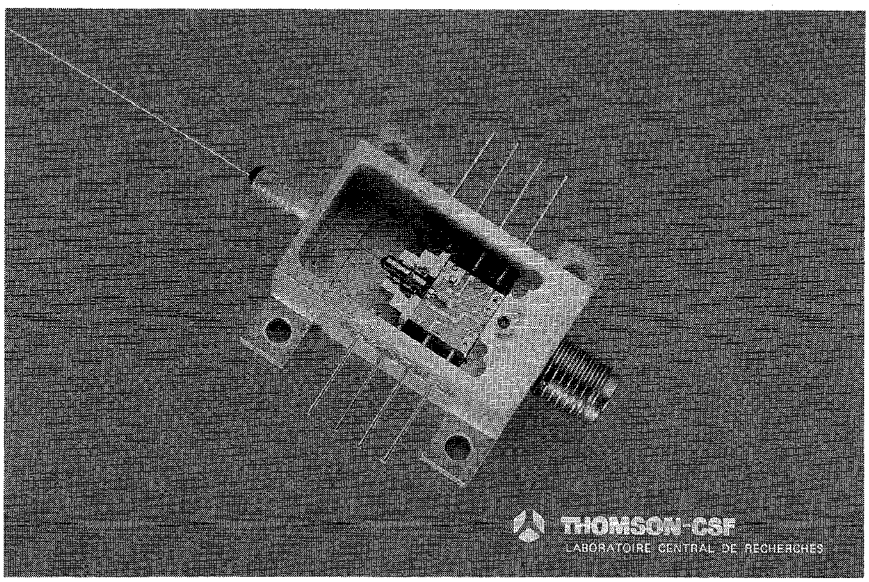


Figure 4

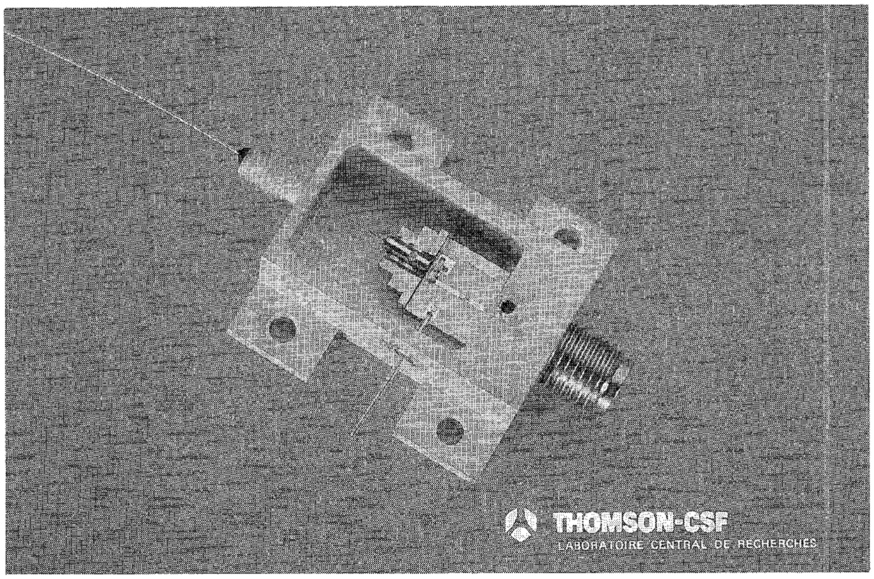
CONCLUSION

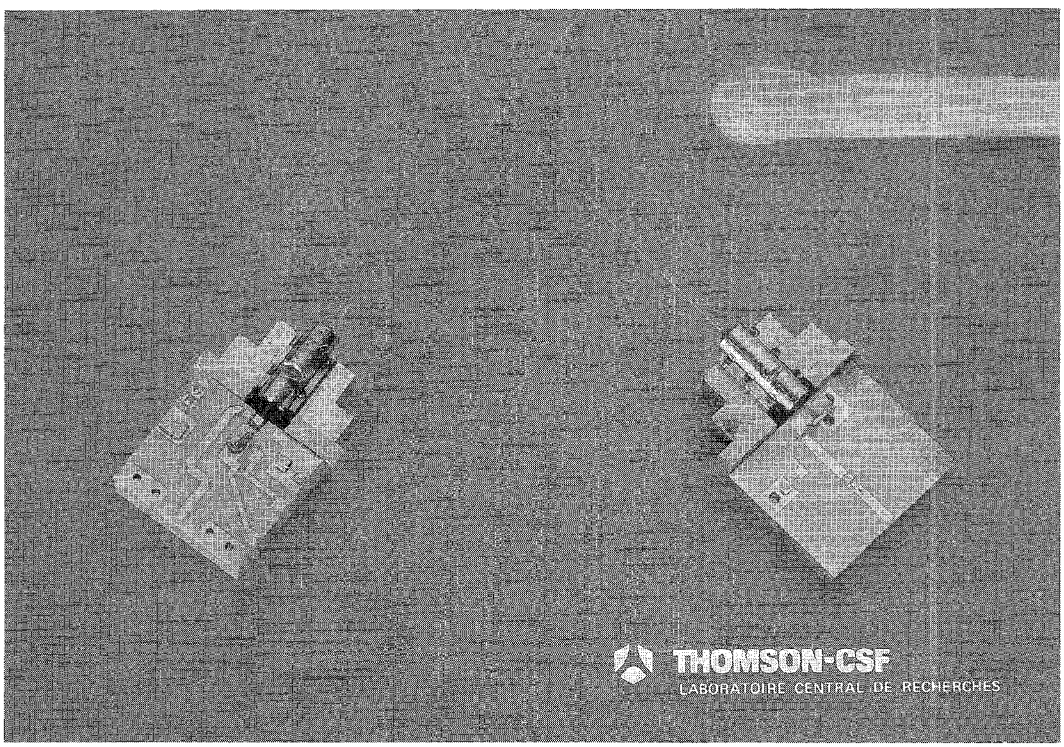
We have developed a new concept of rugged hybrid microwave optoelectronics circuits (transmitter and receiver) which can be used directly into any kind of hybrid design. They are suitable for high speed digital or analog transmissions, in military and space applications. Higher frequencies can be obtained by improving the performances of the chips.

Transmitter module



Receiver module





Transmitter and receiver submodules