Development of fiber-chip coupling methods for use with polymeric fibers

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Abstract **- This paper shows a new method for fiber-chip coupling. To optimize coupling between a light emitting device and a polymeric fiber, special modules were developed. In this paper the measurement results of these modules are presented. Among other things, the PI-curve and the median field were measured and long-term tests were run.**

I. Introduction

Polymer optical fibers (POF) can be used for a large number of applications such as data transmission, sensors and light transmission for signs and illumination. POF systems combine the advantages of optical data communication with a less expensive solution for short distance transmissions [1]. Recent developments in technology and applications have improved the image of POF, and they are finding a larger market with technology companies worldwide.

The three major applications are in industrial-controls, the automotive field and the field of home-entertainment, which will be one of the biggest in the near future.

II. Motivation

First this paper will give a short overview over commercial POF systems. Several companies offer commercial POF systems, in many areas of applications, e.g. Systems like “Ethernet over POF” or MOST, as an automotive application for multi-media transmission via POF [2] [3]. Figure 1 shows complete POF system for transmission of digital audio signals, called TOSLINK from Toshiba Technologies. This system contains a converter with a coaxial input an an optical output, cabels, connectors, splitters etc. Toshiba defines general-purpose optical modules as those having a data rate up to 8 Mbps over distances up to 40 m.

Figure 1: Commercial multimedia POF system

Another important application is for network connections. A CAT5 specified cabel has a transmission length up to 100 m and a transmission ratio from 10/100/1000 Mbps. These are also achievable with POF systems, e.g. with the mediaconverter from the company DieMount, shown in figure 2, a) as duplex module and b) as simplex module.

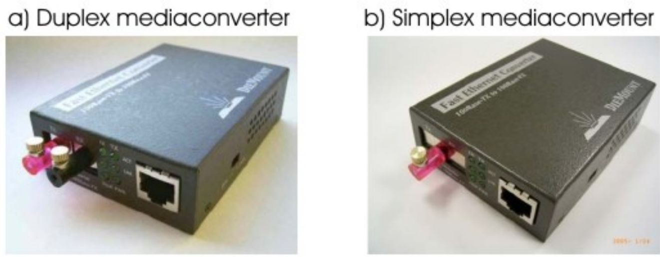

Figure 2: DieMount mediaconverter

In order to advance the development within the range of POF systems, the university currently plans spinning off a start-up company. The main scope of the company is development of full functional POF systems with extendable transmitting rates, using WDM technology [4] [5] [6]. It is planned to use the system as an optical WDM teaching system for students, technichians etc. complete in a package with software and electronic manual. One big advantage is the ability to operate with visible light. Figure 3 shows the WDM system by using three colours or three channels. This will be the thirst step. For seperating the wavelengths (channels) in this step, colour filters will be used. This system is able to tranmitt anolog and digital signals simultaneously. The next step will be the development of integrated optical devices. With help of these devices, it should be possible to use more than three or four channels for transmission.

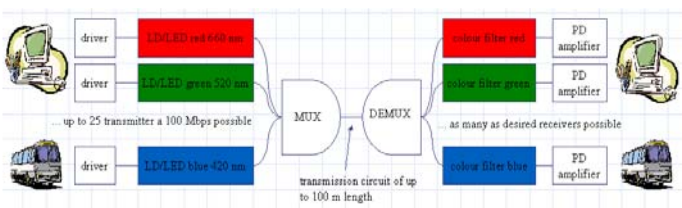

Figure 3: POF WDM system

Another problem is the high attenuation of POF cable and losses at couplers and connectors. Additionally by using colour filters there are losses at the filter foils. Therefore a high power signal is needed to be transmitted through the fiber. Currently there are several efforts to achieve this. One is the development of high power LED’s, e.g. from the company LUMILEDS with their so called Luxeon high power LED’s. Another is to improve the coupling between the OEIC (opto electronic integrated circuit) and the fiber. The company DieMount is pursueing this idea.

III. The Submount modules

The DieMount company developed a special submount module for using in their mediaconverters. Figure 4 shows the transceiver modules for the duplex and the simplex mediaconverter.

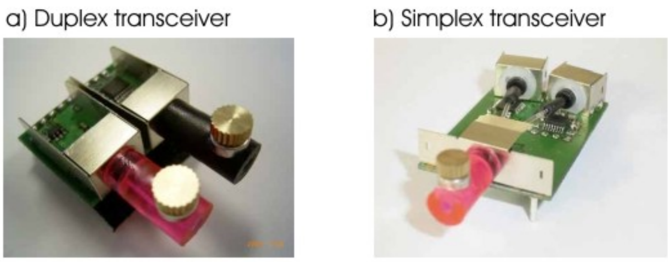

Figure 4: DieMount transceiver modules

The advantages of the simplex transceiver module is that only one fiber is needed. A transmission distance up to 80 m is possible @ 470 nm and 40 m @ 650 nm. The advantage of the duplex module is a higher transmission distance up to 120 m @ 470 nm and 70 m @ 650 nm.

The setup of the submount modules, used for the transceiver modules, are shown in Figure 5.

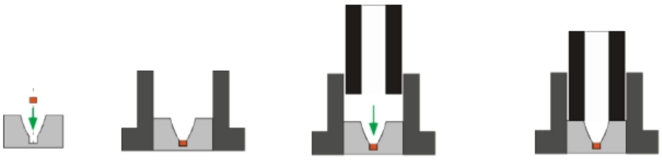

Figure 5: Setup of the submount modules

Step 1: OEIC is placed by passive adjustment in the microstructured submount
Step 2: coupler element will be pressed on the submount
Step 3: now the fiber or connector can be plugged in with the coupler element

These kind of submount modules can be used with LED’s (use for the mediaconverter), VCSEL’s, laser diodes or used for optical receiver elements. The coupling efficiency with the LED modules increased from 11 % up to 58 %. Figure 6 shows such a module which is soldered to the circuit board and a circuit board with several submount elements. [2]

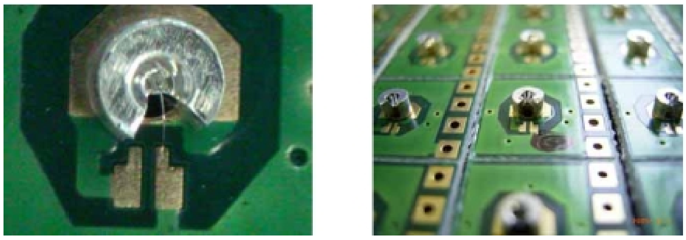

Figure 6: DieMount submount modules

IV. Measurements

The modules measured were setup with laser diodes type “CHIP6505” from Roithner Lasertechnik. According to the datasheet the maximum optical output power of this laser chips is 5 mW.

There are two setups. One by the HHI (Fraunhofer Institut für Nachrichtentechnik, Heinrich Hertz Institut) that is assembled with wedge-wedge bonding using one aluminium wire. They assembled four modules. The second was by the company u2t Photonics in Berlin which are assembled with ball-wedge bonding using three gold wires. They assembled six modules. Figure 7 shows both module setups.

Figure 7: Submount modules

To operate the laser module the submount elements were placed in the Laser diode mount LDH TO3 from Profile Inc. and run with the OEM Laser diode controller ITC 110 from Thorlabs.

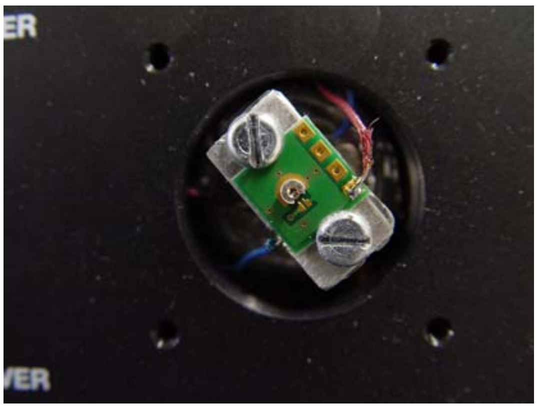

Figure 8: Laser module placed in the diode mount

A. *Medianfield measurement*

1) *Measurement setup*

To measure the medianfield a special method was applied, which was developed by the university itself. To control the measurement a LabVIEW program was developed, which controled the 6-axis-motion system Physics Intrument F-604. For light detection the SI PIN photodiode S7911 from Hamamatsu was used.

For further information about the measurement method please see [8].

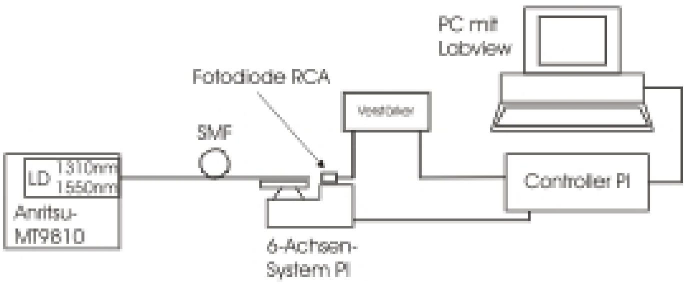

Figure 9: Setup medianfield mesurement

2) *Measurement results*

The medianfield measurement discribes the emitted spotsize of the laser module. The measurement is relative, an absolute value can not be measured. Figures 10 and 11 shows two example medianfields, from a HHI module and from a u^2t module respectively.

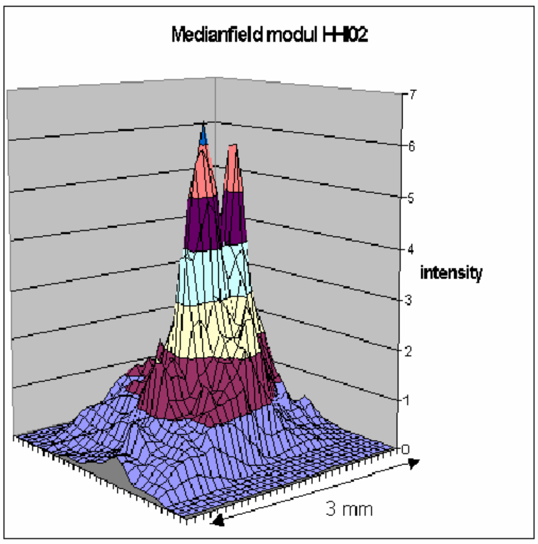

Figure 10: Medianfield HHI module

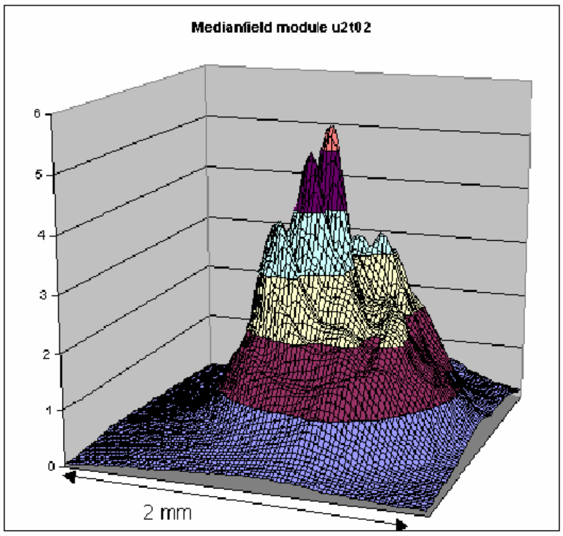

Figure 11: Medianfield u^2t module

The figures show the distribution of the emitted light. They illustrate that there two maxima resulting from the light emitted from both sides of the laser chip. This is an advantages since conventional applications can only use the light emitted from one side of the laser chip. That’s one advantages of this setup. Another is, that with the focusing effect the coupling efficency can be improved. One can see that a standard POF with a core diameter of 1 mm couples most of the emitted light.

Normaly the two spotsizes should have the same behavior. But the submount module is only a prototype and so the surfaces are not handled correctly .

B. *PI curve*

1) *Measurement setup*

For the measurement of the PI curve the laser module was also placed in the Profile diode mount and driven by the Thorlabs laser diode controller. To measure the power a integrated sphere was used with a SI photodiode (range: 400…1100 nm) and the Universal Optical Power Meter 13PDC001 from Melle Griot. With this setup it is possible to measure all of the emitted light.

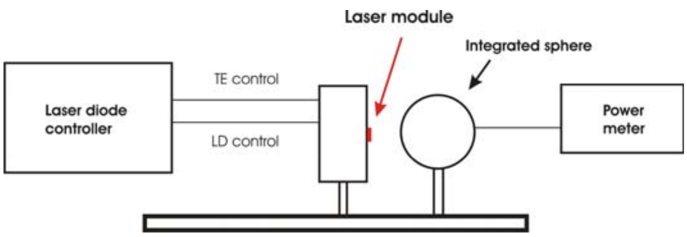

Figure 12: Measurement setup PI curve

2) Measurement results

As seen above, the maximum optical output power of the laser chips is 5 mW according to the datasheet. With this setup it is possible to get much more power. Figure 12 shows the PI curve of a HHI assembled module, figure 13 the PI curve of a u²t assembled module.

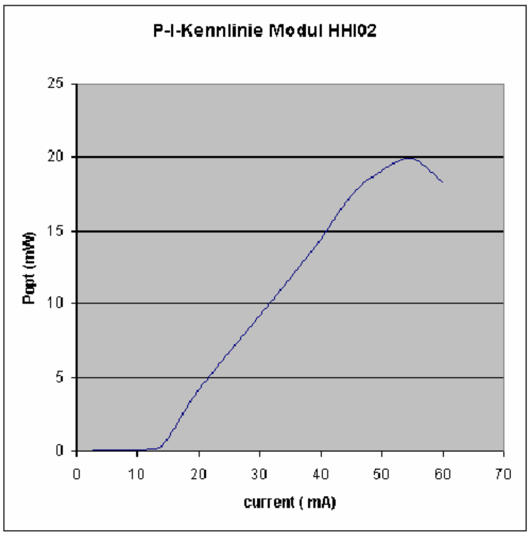

Figure 13: PI curve HHI module 02

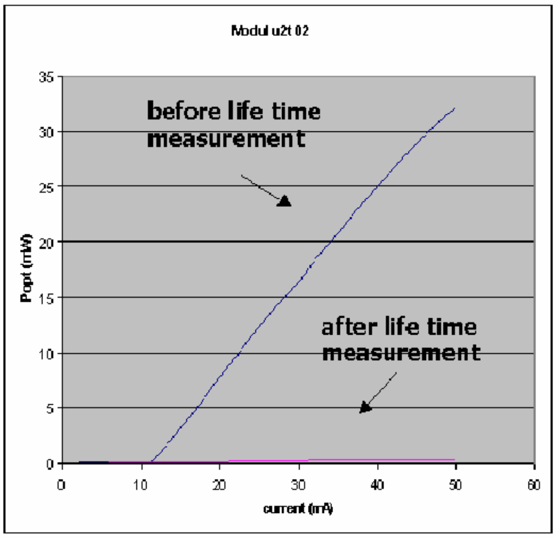

Figure 14: PI curve u2t module 02

It can be seen from figures 13 and 14, that the maximum power of the HHI assembled module is lower than the power of the u²t assembled module. In figure 14 a PI curve after a long term measurement is shown. The curve is more like the PI curve of a LED.

An interesting phenomenon is shown in figure 14. The test series one and two are run with a high power. The test series three to five have a dimished output power. These tests had a strange characteristic curve. Between a current of 30 mA and 35 mA there is a power breakthrough detectable. Test series six was measured after a medianfield test, after the modules death. The curve also looks like a LED curve.

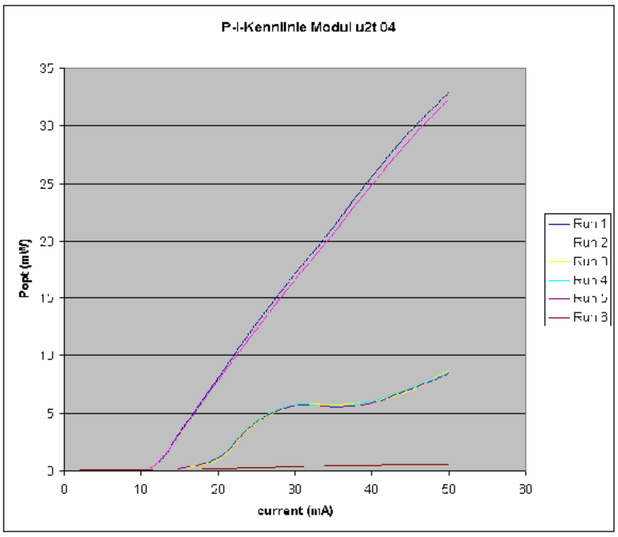

Figure 15: PI curve u2t module 04

C. Life time measurement

The life time is currently the main problem with this kind of modules. The figures 16 to 18 below show long term tests of three modules.

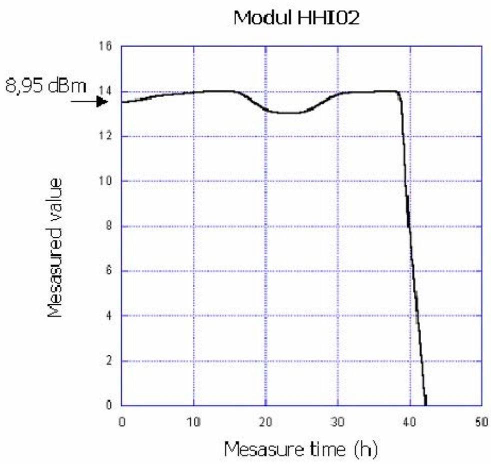

Figure 16: Long term test module HHI 02

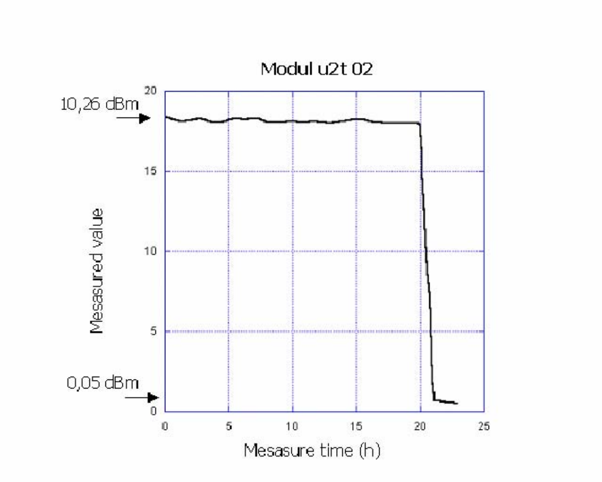

Figure 17: Long term test module u^{2}t 02

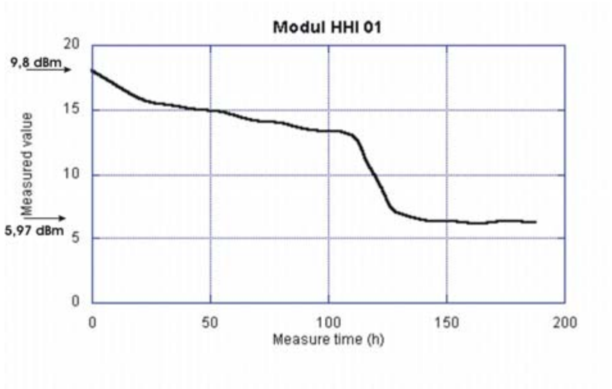

Figure 18: Long term test module HHI 01

Long term stability of the tested modules are different, but in all cases it was not very long. Module HHI 02 (figure 16) runs 40 hours with the full power and then it died, it was not functional anymore. Modul u2t 02 ran for only 20 hours with full power and then it started to act like a LED. The test of the modul HHI 01 runs longer, but with a constantly degreasing output power. After the test it runs compared with the other modules with a relative “high” power at approximate 6 dBm.

There are differences between the individual modules, but not realy between the different construction methods. Last life time test runs longer than one week, but the results not analyzed yet.

D. Statistics

Intotal ten modules were tested. Figure 19 shows how the modules operated before and after the tests. At the end of the measurements, not one module functioned correctly, most of them had a characteristics of a LED.

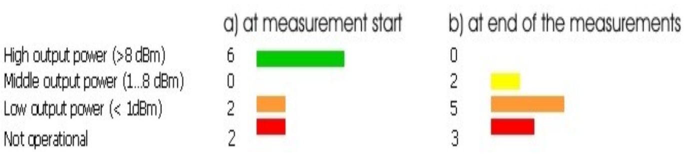

Figure 19: Statistics

V. Discussion

The measurements show that these kinds of modules are a very good method to couple light into a fiber. For future applications it is possible to get more power in an optical trasnmission system, without an increasing current. High power LED’s, like the Luxeon LED’s, are also able to achieve this goal, but they require a much higher current. The tested modules require the same current as normal lasers. The major advantage is the high coupling efficiency.

The long term stability is the only problem with these modules. It was shown, that both setups have comparable results, within the medianfield and life time measurements. There are only small differences in the maximum output power.

By using a different bonding method the problem with restricted life time could be solved. It is very likely that this method of bonding forms micro cracks in the laser chip and therefore reduces the life time of the laser. It is necessery to use another method for bonding, e.g. with a large ball. Some new modules were setup in Taiwan with blue lasers and have good long term stability.

VI. Acknowledgment

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VII. References

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