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Investigation on Homogeneous Trench Assisted Multicore Fiber for Passive Optical Network

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Abstract: We demonstrate trench assisted multicore fiber (TA-MCF) at different spans for a passive optical network using non return to zero-Root Cosine (NRZ-RC) modulation. Further, propose a novel network formation of TA-MCF with core to core rotation scheme for bidirectional parallel SDM transmission. In the proposed system, BER and received power have been observed after WDM/SDM transmission.

Keywords: Homogenous TA-MCF, Amplifiers, NRZ, RC filtering.

1. INTRODUCTION

In order to survive up with the predictable capacity crunch, the goal of next cohort optical transmission system is to expand the transmission capacity [1-2]. In order to achieve this, the multicore fiber has been described [3-4]. Further SDM based on homogeneous and heterogeneous multi-core fiber (MCF) has been reported with transmission capacities 305Tb/s and 2.05Pb/s using polarization multiplexing-QPSK, respectively [5-6]. Nevertheless, the transmission distances were confined to 10.1km with SDM homogeneous and heterogeneous MCF. It is vital to upsurge the transmission distance using numerous spans of MCF for long tow application while taking care of crosstalk between neighboring cores and span losses. Tapered multi-core couplers (TMCs) are used to perform multiple spans of MCF for long haul transmission with low span loss and low-crosstalk [7].

In earlier efforts, various modulation techniques for passive optical network has been reported such as NRZ rectangle [8], hybrid PON [9], Ethernet PON [10] and re-modulation scheme with different modulation formats [11] etc. But it is limited to 50km distance for 8 users, 28km distance for 128 users, 30 km distance for 16 users and 150 km for 64 users respectively.

In this work, we extended the previous work by TA-MCF at different spans using the core to core rotation scheme for a passive optical network.

This paper is ordered as follows. In Section 2, theory and Design of Homogenous TA- MCF with TMC is described. Simulation Set up is described in Section 3. Results are presented in Section 5. Conclusions are given in Section 6.

2. THEORY OF TA-MCF WITH COUPLER

The trench assisted-Multicore fiber is projected for accomplishing high capacity and spectral efficiency, which is being operated for uplink and downlink transmission at 1490nm for and 1550nm wavelength. For achieving squat macro, micro bending losses and crosstalk, a trench assisted Multicore fiber is investigated.

There should be fine coupling between the exterior components of solo core and between cores to core in every span for extensive heave transmission. To minimize the consequence of power coupling between the cores of TA-MCF, Trench assisted multicore fiber is coupled with two TMC's as shown in Figure1. In which, input and output end of TA-MCF is attached with TMC. In every core of the 2 TMCs, insertion loss differs and between each core, inter core crosstalk is less [12].

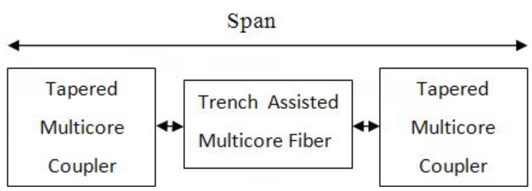

Figure 1: Coupling of TA-MCF with TMC

3. EXPERIMENTAL SET UP

The system set up of TA-MCF for PON is shown in Figure 2. It consists of an optical line terminal (OLT), optical network unit, TA-MCF with TMC and 1:64 splitter and combiner. Seven OLTs are transmitted and received over TA-MCF with inline amplifiers to boost the performance and further sent to 1:64 splitter combiner block with 0.50 coupling factor which is received by 448 users. The uplink and downlink wavelengths are tuned at 1490nm for downlink and 1550nm for uplink with the data rate of 10Gbps and 2.5Gbps respectively. In OLT, pseudo random data sequence generator provides the data rate of 10Gbps and is converted into electrical pulses using NRZ RC filtering.

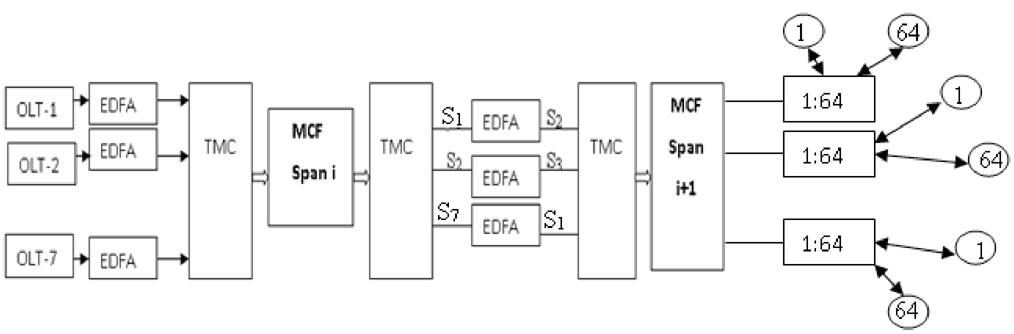

Figure 2: Block diagram of WDM/SDM transmission system

These electrical pulses are converted into an optical signal using Mach-Zehnder modulator. The seven uplink and downlink signals from OLTs were transmitted over TMC coupled TA-MCF with Erbium doped fiber amplifiers using seven recirculating span loops (i = 7) for SDM transmission. The signals at each of the seven loop inputs were first amplified by erbium-doped fiber amplifiers (EDFAs) before being launched into an 11.3-km seven-core-fiber through a TMC. For efficient coupling, another TMC was used to get the signals at

MCF output. The uplink and downlink signals from seven OLTs (S_1, S_2, ..., S_7) originated into seven cores of a TA-MCF span which are further travel through spatially different cores in the next TA-MCF span and core to core rotation persist along the TA-MCF transmission fiber link. In-line amplifiers are used with TMC couples TA-MCF. During the 1st span ($i = 1$), the signals are transmitted through cores (from 1^{st} core to 7^{th} core) and in 2^{nd} span ($i = 2$), they would be transmitted through 2^{nd} core to 1^{st} core. This process is repeated seven times and signals will be transmitted through different cores at each span. The signals are received by 448 users at ONU with the help of 1:64 splitters and combiners at a distance of 79.1km.

4. RESULTS AND DISCUSSION

Simulation results of BER performance for 7-core bi-directional SDM transmission distance over 11.3km TA-MCF with 7 spans are shown in Figure 3. The BER defines the probability of incorrect bits by decision circuit at the receiver. The BER at center core ranges from 2.27×10^{-25} to 2×10^{-5} with respect to distance from 11.3km to 79.1km. The acceptable BER of 2×10^{-5} is achieved for downlink at the center core after covering 79.1Km of transmission distance. It is also observed that best BER is achieved at center core comparative to all other cores because there is minimum crosstalk −17dB at the center core for downlink transmission.

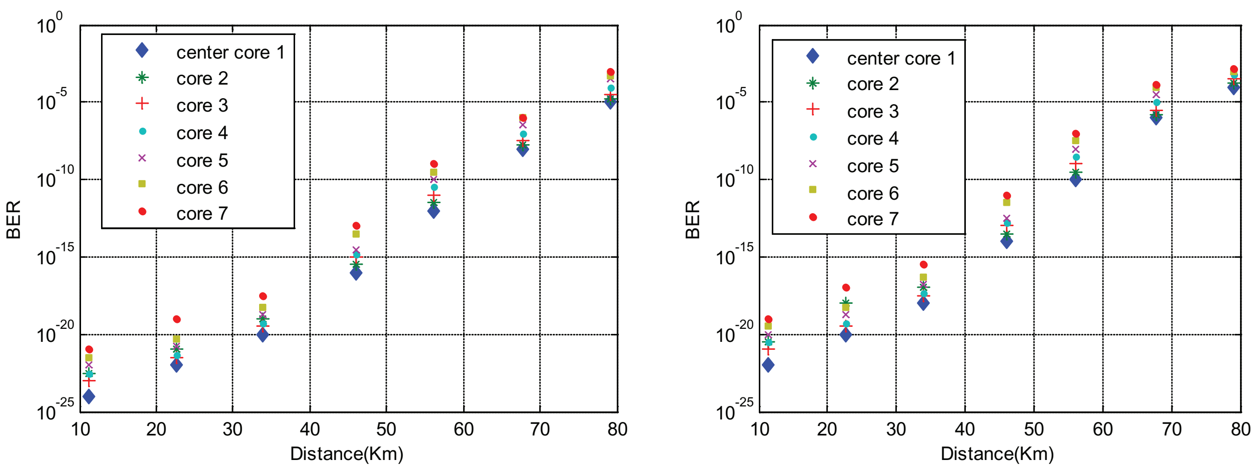

Figure 3: Simulation results of BER performance for 7-core bi-directional SDM transmission distance over 11.3km TA-MCF with 7 spans (a) BER performance as a function of distance for downlink (b) BER performance as a function of distance for uplink

Figure 3(b) shows the variation of BER as function of distance for uplink. The BER at center core ranges from 2.27×10^{-22} to 2×10^{-4} with respect to distance from 11.3km to 79.1km. The acceptable BER of 2×10^{-4} is achieved for downlink at the center core after covering 79.1Km of transmission distance. It is also observed that best BER is achieved at center core comparative to all other cores because there is minimum crosstalk −25dB at the center core for downlink transmission as shown in Table 1.

At the center core, there is minimum crosstalk as compared to other cores. The variations in the BER are low from all seven cores, demonstrating the advantage of core to core rotation at every loop to balance the performance of all seven cores.

5. CONCLUSION

In this paper, TA-MCF is used for bidirectional transmission in passive optical network (PON). The proposed PON can successfully transmit the data at the speed of 10Gbps and 2.5Gbps for 448 users up to 79.1km transmission distance. From the results, the acceptable BER is achieved from all cores with minimum crosstalk by 448 users.

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