Reducing the Optical Component Cost for Future Fibre Access

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Abstract *Next generation fibre access will require components with performance comparable to today's long-haul DWDM but at GPON prices. This paper outlines the role of "colourless" technology and photonic integration in helping meet this challenge.*

Introduction

The Internet is moving rapidly to a next phase of evolution driven by video centric applications. The bandwidth required for these services will be further accelerated by the widespread consumer adoption of large flat panel displays with an expectation of increased availability of high definition content. If HD follows the same explosive growth as "over the top" low definition video services then the delivery capability of both VDSL and GPON will be outstripped sooner than the planners anticipated.

Ideally, a next generation optical access network must be designed from the outset with the ability to handle this huge potential growth. However, an affordable network has to assume that network revenue growth will follow a much lower trend line. The classical TDMA PON conceived to reduce the cost of the fibre plant through shared access may not be the best solution to provide the capacity needed for these new services, especially if split ratio and reach is increased to improve initial installation economics. To overcome contention limitations there is growing interest in the use of WDM technology to increase the capacity of a shared fibre access network without the need for ever higher speed ONU optoelectronics to handle the aggregated network data rate. WDM can be used either as a method to provide each user with sole access to a wavelength, giving a contention free virtual point-to-point connection, or in combination with TDMA to increase the shared capacity of a classical PON.

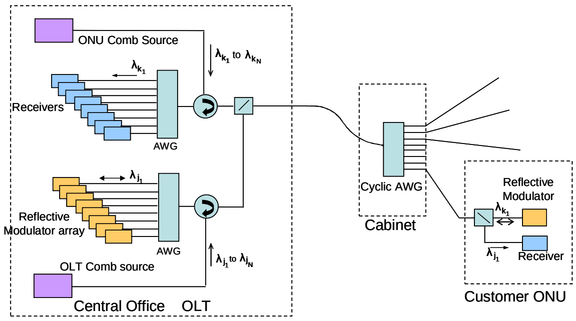
Whilst first generation commercial WDM-PON systems have already been deployed the economics are not yet attractive for widespread FTTH application. To broaden acceptance there has to be significant reductions in the cost of WDM technology whilst maintaining certain key performance attributes. This paper will focus on two important trends which will help achieve this, namely, "colourless" DWDM and photonic integration.

Component Requirements for WDM in Access

If WDM is to be extensively deployed for FTTH it is essential that the transmitter in the customers ONU should be "colourless" to avoid huge inventory issues. The "colourless" transmitter can be achieved in two ways, the most obvious is to use a tuneable laser, but this requires new design approaches as the cost of DWDM tuneable lasers currently used in long haul transmission would be far too expensive. The second approach is the reflective architecture where only a modulator is required within the ONU transmitter. For symmetrical WDM-PON schemes, which are those that do not have a TDMA overlay, there is also a strong need to reduce the cost, footprint and power consumption of the OLT optics.

At CIP we have been developing alternative transmitter technologies for both reflective and tuneable WDM-PON architectures. Fig 1 illustrates a simplified example of a reflective WDM-PON architecture showing some of the key components.

Fig. 1: Reflective Architecture



Within the reflective WDM-PON architecture a centrally located comb source sends CW light to an array waveguide (AWG) splitter element within the network. The AWG directs a separate wavelength to the reflective modulator within the customers ONU and this is modulated by the customer data and returned to the OLT via the same AWG. As an alternative to a centralised laser comb source it is also possible to use a spectrally sliced ASE source, such as an EDFA or SLED in lower capacity (GbE) and shorter reach (<20km) systems which are not limited by noise or dispersion. The reflective modulator can take several forms, one solution is to use a reflective semiconductor amplifier as this provides both modulation and gain[1]. These devices work well with simple drive circuits up to 2.5Gbit/s and can be stretched to higher rates under special drive conditions. The RSOA is essentially a laser structure but with the reflection almost entirely suppressed from

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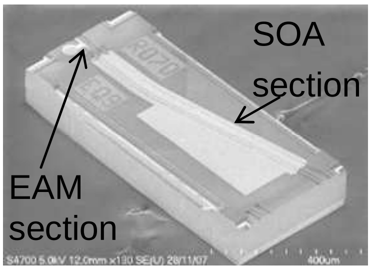
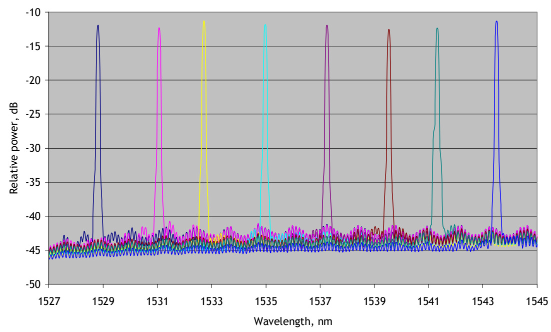
one facet. This is achieved in a structure featuring curved waveguides, mode expansion and ultra-low antireflection coatings. At high manufacturing volumes the RSOA chip is expected to be a little more expensive than a Fabry-Perot laser, probably comparable to a DFB laser, but not as expensive as a tuneable laser. For 10Gbit/s data rates a better solution is use an integrated SOA-REAM for the reflective ONU transmitter. This provides the amplification advantage of the SOA but with the modulation speed of the EAM. An integrated SOA-REAM has been developed on 6th Framework project PIEMAN and has proved capable of long reach transmission over 80km at 10Gbit/s [2].

Fig. 2: Integrated SOA/REAM Chip for reflective ONU



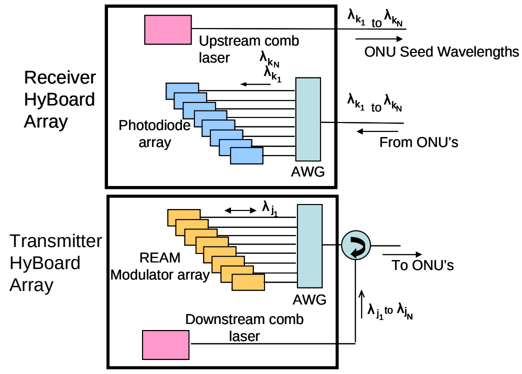
The alternative to the reflective architecture is to use tuneable lasers within the ONU. A tuneable laser designed at CIP for long reach DWDM access has been recently been demonstrated on the PIEMAN test-bed at the UCC Tyndall Centre[3]. An objective of the laser design was to eliminate the need for either internal wavelength lockers or network centric wavelength stabilisation. Ideally the laser wavelength needs only to be set once when the ONU is first brought into service. To achieve this high level of inherent stability a hybrid integrated laser design has been developed featuring an athermal tuning filter set by a micro-motor of a type produced for consumer applications. A side mode suppression ratio of better than 30dB is achieved over the required tuning range, as shown in Fig 3.

Fig. 3: Tuning spectrum of hybrid integrated ONU laser



Within the OLT of a WDM-PON there is also a need to reduce optical component costs. At the OLT photonic integration offers a great opportunity not only to reduce cost and size but also eliminate the fibre spaghetti of a discrete component solution. Hybrid integration has particular attractions because it provides the best economics for combining passive elements, such as AWG's and active devices, including lasers, modulators and amplifiers. A critical feature of the hybrid integration approach is the ability to self align the InP based active devices and the silica on silicon passive components[4]. This requires the use of mode expansion on the active elements along with various lithographically defined alignment features on the silicon motherboard and sub-mounts. With this approach fully automated "pick and place" assembly is a long term possibility to reduce costs. A prototype 32 wavelength DWDM laser source using hybrid integration has recently been demonstrated in a WDM-PON[5]. Fig 4 shows how both the footprint and number of fibre connections within the equipment of a reflective WDM-PON OLT could be further reduced using photonic integration.

Fig. 4: Possible Hybrid Integrated Modules for WDM OLT



Discussion and Conclusion

DWDM technologies will be required in future optical access to achieve the required capacity and "colourless" transmitters will be a critical element to achieving this. Whilst the ONU is principal focus of attention for component cost reduction in a TDMA PON the symmetrical nature of a WDM-PON architecture means that the OLT cost must also be considered. Within the OLT photonic integration will be needed to reduce cost and footprint. Moreover, with the right choice of integration technology we believe it should ultimately be possible to achieve cooler-less operation of DWDM modules leading to significant reductions in power consumption. Components for next generation access should strife to be "compact, colourless and cooler-less"

References

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