OPTICAL AND MICROWAVE COMMUNICATION USING NEW MATERIALS – an Overview

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Introduction

The idea of this paper is to present optical and microwave systems making use of new materials. Materials science as an interdisciplinary field has pushed on the development of revolutionary technologies such as polymer, semiconductors and nanomaterials.
The optical fiber is the most common medium for modern digital optical communication which permits transmission over long distances at high data rates. Light is travelling in the fiber core by total internal reflection. Moreover, it is possible to select glasses with sufficiently matched thermal properties; it is likely that hot embossing of glass-based matrices offers an extremely promising route for producing high-resolution, guided-wave optical components and circuitry at low-cost, high volume, and for a wide wavelength range [1].
There are fiber lasers with an active gain medium applying rare-earth doped elements such as erbium, ytterbium, neodymium, dysprosium, praseodymium and thulium. They are related to doped fiber amplifiers which provide light amplification without lasing. Diodes which are electrically pumped are semiconductor lasers such as GaAs and InP. Vertical cavity surface-emitting lasers (VCSELs) are semiconductor lasers emitting perpendicularly to the surface of the wafer.

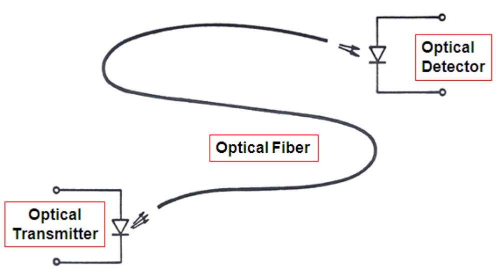

Fig. 1 – Basic arrangement of a fiber-optic system

Broadband network architecture uses optical fiber to replace all or part of the usual metal loop for last mile communications. In outer space, the communication range of free-space optical communications is currently in the order of several thousand kilometres, but has the potential to bridge interplanetary distances of millions of kilometres, using optical telescopes as beam expanders.
The word "fiber" is a synonym for the future, for speed and quality.
But communication systems are also used for recent application areas in the MBit/s region, e.g. in aviation, automobile and maritime industry. Therefore - besides pure glass fibers, polymer optical fibers (POF) and polymer-cladded silica (PCS) fibers have to be taken into account. Moreover even different physical layers like optical wireless and visible light communication can be a solution.
Also combinations between fiber-optic and microwave techniques have been developed, Radio over Fiber (RoF)- and Radar-Systems

Experimental achievements

Since the beginning of the sixties, there has been a light source which yields a completely different behavior compared to the sources we had before: This light source is the LASER. The first realized laser was the bulk-optic ruby laser [2]. Short time after this very important achievement diode lasers for use as optical transmitters have already been developed. Parallel to that accomplishment in the early seventies, researchers and engineers accomplished the first optical glass fiber with sufficient low attenuation to transmit electromagnetic waves in the near infrared region [3]. The photodiode as detector already worked, and thus, systems could be

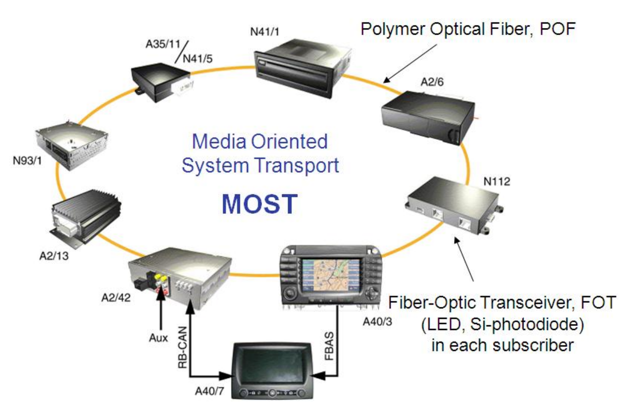

Fig. 2 MOST network with ring topology

developed using optoelectric (O/E) and electrooptic (E/O) components for transmitters and receivers as well as a fiber in the center of the arrangement (Fig.1). These systems can operate as transmission links with bit rates up to 40 Gbit/s.

Actually for cars they are mainly used in the infotainment domain (MOST, Fig.2). Current data rates are in the order of 150 MBit/s. Consequently, the use of LEDs and polymer optical fibers (POF) is sufficient. For higher data rates, also alternative solutions are discussed: The LED as transmitter can be replaced by a VCSEL and the POF by a polymer-cladded silica (PCS) fiber [4]. Due to the inherent fact that, as a result, the fiber diameter is reduced, the detector area of the well-known Silicon photo diodes can also be reduced greatly. As a consequence, data rates can be extended into the Gbit/s-region.

Optical wireless transmission offers several motivations: There are no problems with electromagnetic interference (EMI), electromagnetic compatibility (EMC) and e-smog.

Thus, robust use in RF-sensitive environments can be achieved. Simple shielding by opaque surfaces guarantee no crosstalk between rooms, inherent protected privacy and insensitivity to remote sabotage. Basic configurations for wireless led transmission are line of sight (LOS) and none line of sight (NLOS) setups (Fig. 3). Possible application areas office labs (e.g. due to white LED-panels), home area networks, mobile phones or laptops (point to point data transmission for high speed uploads/downloads) [5].

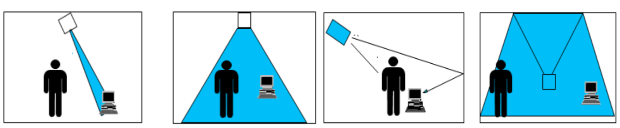

Fig. 3 LOS and NLOS wireless transmission

Radar systems can possibly be used to review conditions of limited optical visibility (fog, snow, rain, high smoke content, etc.). Possible application areas are: control of movement of ground vehicles, search landing places for planes and helicopters and search for objects of natural and artificial origin on earth. Furthermore the system can be used for visual control or for other situations where optical or IR-gauges are too difficult or impossible to use. Radar systems working in a resolved frequency range do not influence other radio-electronic devices. One practical application is the automobile radio vision system, ARVS. It generates a radar-tracking image (RI) of the road. This gives the driver an opportunity to observe precisely the road borders, cars, other subjects and obstacles within the limits of the working range even if there is no visibility (Fig. 4).

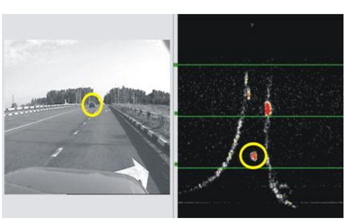

Fig. 4 Radar measurement

Fig. 5 shows a Radio over Fiber (RoF)-Systems building a bridge between fiber-optic and microwave techniques [7]. Instead of a repeater spacing of 400 m by WLAN use only now we achieve an extension to 2 km.

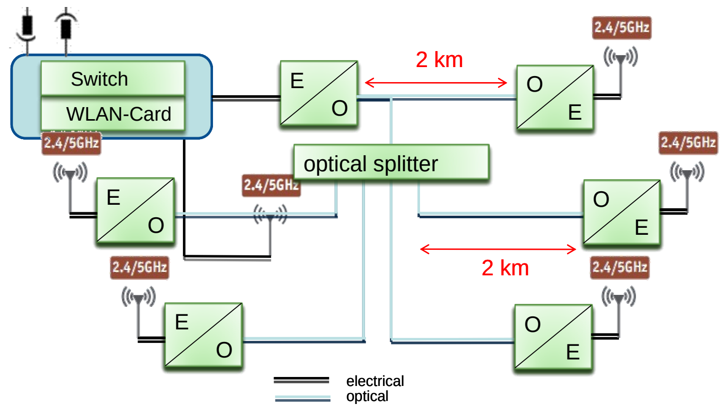

Fig. 5 Trainguard MT Metro Shanghai RoF-WLAN Transmission System

Conclusions

A brief introduction to pure-optical, fiber-optic, Radar, WLAN and hybrid transmission systems was given. Principle operations and first promising experimental results in telecom and automotive applications have been shown – not being possible without use of new materials.

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