Development of investigations in the field of optical fibre technology

Present optical fires have already over 25-year history. They were invented for the needs of telecommunication but nowadays they stimulate development of other branches of economy. The beginning of optical fibre technology development is dated back to 1970, in which year first optical fibres were produced in American and Japanese laboratories enabling transmission of light at a distance of more than 1 km. These were quartz optical fibres.

In the second half of the seventies, step-index optical fibres were replaced by graded-index fibres with lower dispersion. At the turn of the seventies and eighties, a technology of single-mode optical fibres was worked out, which in the second half of the eighties began to dominate in telecommunication applications.

Simultaneously with the development of the technology of optical fibres, and especially reduction of the level of contamination with groups OH, the transmission wavelength increased from I transmission window (850 nm) to II (1300 nm) and III (1550 nm). Today single-mode fibres cover about 90% of telecommunication optical fibre market (graded-index fibres are applied in quantities of about 10%).

Invention of optical fibres admixtured with rare earth elements in the middle of the eighties contributed to construction of optical amplifier EDFA (Erbium Doped Fibre Amplifier) at the turn of the eighties and nineties. The amplifier EDFA is presently applied on a large scale to build telecommunication tracks WDM (wave division multiplexing). Difficulties connected with construction of optical fibre tracks with many channels and optical amplifiers (HDWDM — high density wave division multiplexing) have been overcome in recent years by invention of new single-mode non-zero dispersion-shifted optical fibres in the Bell and Corning laboratories.

At Maria Curie-Skłodowska University investigations of fibre optic technology were initiated in 1975, and in 1978 a Polish version of optical fibre production method MCVD (Modified Chemical Vapour Deposition) was worked out. There were manufactured multimode fibres and then a cable of 2.5 km in length containing 4 fibres was made. This cable was used at the beginning of 1979 to build telecommunication line connecting two telephone exchanges in Lublin. In this way, Poland ran into the group of seven countries having fibre optic telecommunication lines. It was the first fibre optic line in socialist countries, which fact marked the beginning of the development of optical fibre telecommunication in Poland. The Optical Fibre Plant was built in Lublin, in which advantage was taken of the technology provided by the UMCS and then industrial production of optical fibres started.

The second trend in the development of optical fibre technology were special fibres from quartz glass. Already in the second half of the seventies, first fibres maintaining polarization were produced, being intended for heterodyne transmission in telecommunication. However, they did not find application in telecommunication, but nonetheless they made it possible to invent many kinds of fibre opric sensors and at present are produced by several firms.

In order to construct sensors polarisation fibres were also invented (commercially available) and, besides, a technology of side-hole optical fibres (with very high selectivity and sensitivity to pressure) was worked out in Poland a year ago.

A large group of optical fibres are fibres from quartz glass with large diameter of core and large aperture: all silica, plastic clad silica and hard clad silica fibres. They are mostly used for transmission of high power of laser radiation, for construction of simple sensors (including chemical sensors) and for data transmission at short distances (up to 1 km).

In the last years, a rapid increase is observed in application of plastic optical fibres (POF — plastic optical fibre) for data transmission at short distances (up to 100 m), especially after invention of graded-index POF in Japan, enabling transmission of Gbit/s at a distance of 100 m. Plastic optical fibres are laso used for lighting and decorative purposes.

Multicomponent glass fibres, in spite of intensive technological investigations in the seventies, did not find use in telecommunication because of too high attenuation. Today they are used for transmission of light at very short distances (several tens of meters) and in construction of endoscopes and elements of fibrous optics.

Intensive work on technology of fibre production from non-oxide materials with theoretically foreseen attenuation of 0.001 dB/km was carried out in the eighties. The lowest attenuations of fibres produced in laboratory conditions were a bit less than 1 dB/km.

Attenuation of fibres produced at present from non-oxide materials (especially ZBLAN on the basis of ZrF4) amounts to tens of dB/km. They are used on a small scale for transmission up to 5 μm. In far infrared (up to 15 μm) polycrystal non-oxide materials are used, but their attenuation equals about 1000 dB/km.

As regards economic effectiveness, there definitely dominate optical quartz glass fibres, especially telecommunication fibres.

Production of telecommunication fibres reached in 1997 the level of 36 mln km and foreseen dynamics of an increase in this production is about 20% per annum.

In the second place, plastic optical fibres should be listed, then multicomponent glass fibres from glasses multiple and fibres from non-oxide materials.

Investigation is directed towards new types of optical fibres for telecommunication purposes and non-telecommunication fibres, new raw materials for production of special optical fibres and new production methods. A very essential trend is investigation on how to increase the efficiency of telecommunication fibres production (sol-gel method, hybrid methods) in order to lower the price upon dynamically rising demand.

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