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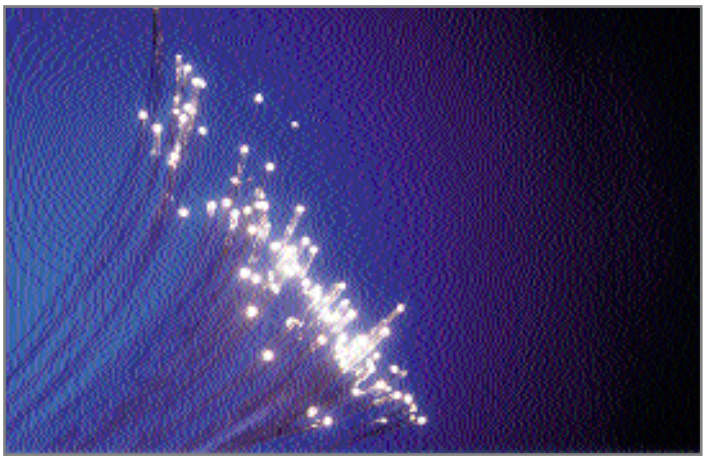

Plastic Optical Fibre • POF

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Plastic optical fibres provide a new, flexible alternative for LAN connections

Gilles Widawski, Director of Nexans' Corporate R&D centre in Lyon, France explains how the flexibility and ease of installation offered by plastic optical fibre (POF) means that this new technology is set to challenge traditional local area network (LAN) connections.

What is POF?

In principle, Plastic optical fibre (POF) is similar to the standard 'glass'optical fibre (GOF) which is now in common use for data & telecommunications.
All optical fibre cables work by transmitting pulses of light along the length of the fibre and then reading the signal at the other end. In order to receive a good signal over a long distance the transparency of the fibre needs to be very high, which means using very pure materials and clean processes.
Until recently limitations in the quality of plastic materials and processes meant that the high signal attenuation of POF restricted its use to lighting applications.
However, the latest advances in technology have now proved POF capable of delivering over 10 Gbit/s for more than 100 m, which makes it a potential competitor to both copper and GOF for high data requirements in both commercial and domestic LANs and network interconnections.

Step index (SI) POF - in development since the 1960s

Dupont produced the first POFs in the late 1960s. The aim was to take advantage of the mechanical characteristics of polymers and their simplicity of use to produce an optical fibre with a much larger core diameter than that of glass fibres (1000 µm compared with 9 µm) which would make connection much simpler.

The insufficient purity of the material used at that time - namely polymethyl-methacrylate (PMMA) – resulted in an attenuation level of 1000 dB/km, which was unacceptable for communications applications. Technological progress during the 1980s made it possible to reduce the attenuation to the intrinsic value of the material, 130 dB/km at a light wavelength of 650 nm. This has enabled the industrial development and commercialisation of the 'step index' (SI) POFs, which generally consist of a PMMA core (980 µm) and a fluorinated polymer cladding, with a lower refractive index than the PMMA (cladding thickness 20 µm). Because it has a limited propagation speed (200 Mbits/s over 100 m), SI POF is used for short distance applications such as in cars, videos and mini-disk players. In vehicles in particular it offers a dual advantage over copper harnesses by eliminating the problems of electromagnetic interference (EMI) and offering weight savings, while at the same time ensuring ease of connection.

GRIN - upgrading performance to 10 Gbit/s.

For the telecommunications and network engineer, the most important parameter for an optical fibre - apart from spectral attenuation - is its bandwidth.
The introduction of **GR**aded refractive gradient **IN**dex (**GRIN**) POF offers performance levels that are a hundred times better than SI. GRIN POF is manufactured from a highly transparent perfluorinated polymer (CYTOP). It allows high-speed transmission over long distances and its key advantage is that unlike SI POF, which can only be used in the 650 nm (visible light) window, GRIN POF can operate in the infrared (850 nm to1300 nm) window used for data communications. It also enables the possibility of making multiplexed links over a wide range of wavelengths.

By 2000, work on GRIN POF had progressed to the point where it can offer 10 Gbit/s over 100 m at 850 and 1300 nm. Thanks to its mechanical characteristics and ease of connection, GRIN POF is the medium that is being developed in short-distance, high-speed LAN applications.

POF manufacture

The standard processes for the manufacture of Cytop POF is similar to those used for glass optical fibres. The starting point is the production of a preform, which is heated and then drawn into fibres. An alternative process for the manufacture of GRIN POF is by extrusion from polymer granules.

The basic manufacturing process is actually simpler than with GOF since there is no need to vapour deposition techniques. Furthermore, it is not necessary to apply the two layers of coating required for GOF and a much simpler and shorter drawing tower is required, compared with the 30 m required for GOF.

At the Nexans Research Centre (NRC) we are developing the process based on the preform technology.

POF applications

POF has potential applications in the following domains:

- LANs (local area networks), building horizontal and vertical network cabling
- residential network cabling (SOHO standard: Small Office and Home Office)
- optical interconnections in telecoms and LAN equipment
- industrial applications (monitoring, data acquisition)
- automotive and aeronautics

Local area networks – copper versus optical fibre

LAN applications today make major demands of the cabling systems, especially for ultra-fast data transmission protocols such as Gigabit Ethernet or Gigabit ATM where the infrastructure is often in advance of the transmission speed demand. The demonstrated capability for POF to achieve 10 Gbit/s over 100 m makes it compatible with the future 10Gigabit Ethernet standard.

The rival merits of optical fibre versus copper for LANs is the subject of great debate. GOF has been used for almost 20 years, however for the last ten years or so, copper pairs (UTP) have progressed from generation to generation (category 5, 6 and 7), each time to remain compatible with the LANs' growing bandwidth demand. Copper cable manufacturers have been rewarded for their technical efforts in improving the capacities of UTP cables, assisted by the responsiveness of active equipment manufacturers who have also improved compression and encoding techniques.

Even so, copper has a few drawbacks that make fibre attractive. Increasing the performance of a copper pair requires the designing of higher-performance connectors and more precautions when making the connection (excessive untwisting of the wires or removing too much sheathing can cause serious faults). Electromagnetic interference can be a serious handicap in many applications.

Some network architectures requiring longer transmission distances and faster transmission speeds, or the need to be a step ahead of the increases in transmission speed, can render fibre more attractive. Finally the 10Gigabit Ethernet standard might make things difficult for copper cabling solutions.

Advantages of POF against GOF

GRIN POF has numerous potential advantages over multimode glass fibre. For example, with GOF, which typically has a core diameter of 50 µm the light source must be positioned precisely in the centre – within a few µm – otherwise there will be a very significant signal loss. GRIN POF though has a much bigger core diameter, typically over 120 µm, so the exact centring of the light spot is less crucial. This makes connections much easier and less expensive. In addition, since there is no coating to remove, polishing is simpler, or even unnecessary. So unlike GOF, which has to be supplied with fitted connectors, it is perfectly feasible to supply POF on a reel to be cut to length on site and connected as needed, just like copper.

GOF also has limited flexibility, with a maximum bending radius of about 40 mm, while the flexibility of POF enables it to twisted into any direction without breaking or loss of signal. A further advantage of POF is that it offers the possibility of using the same physical support for horizontal cabling (fibre right up to the workstation) and for the network backbone.

Residential network cabling

The profusion of home PCs, high-speed internet access and the ever growing sales of digital equipment (recordable DVDs, digital cameras, printers, scanners), mean that the home world is becoming increasingly digital. The result is a gradual convergence of telecommunications, computing technologies and digital audiovisual systems to the point where the consumer will no longer have independent items of equipment but will instead have a variety of interactive systems dotted around the house.

Due to the large volume of the video content on the network (from video on demand applications etc) this digital household will require hard-wired interconnections. POF offers a physical means of transmission that provides large bandwidth (> GHz.km) beyond 50 m, and is very simple to use. It offers numerous advantages: its large core diameter means it is simple to use and the connectors are inexpensive. POF has been chosen by the consortium coordinated by the electronics giants Sony, Matsushita, Philips, Apple for IEEE 1394, which defines the links and communication protocols for multimedia applications.

Interconnections in datacommunications and telecoms facilities

There is an ever increasing need for high-speed interconnections capable of eliminating the bottlenecks in network switching facilities. GRIN POF offers the possibility to meet this demand by providing interconnections capable of 10Gbit/s over the short distances required (up to 100 m) with superior performance compared to copper coax and at a lower cost than GOF. Nexans has already tested ribbon connections capable of providing eight x 10 Gbit/s connections over 100 m.

Installing and testing POF

POF combines the installation benefits of copper with the transmission advantages of GOF. It can be cut, joined and connected with simple crimp and clip tools so much less installer training is required than with GOF. Testing is carried out at 850 nm and the routine is similar to GOF, all that is required is a change to the appropriate connector. There is only one main drawback to POF, which is that it is limited to use at temperatures below 80°C.

Costs and availability

POF is an emerging technology and installed experience in Europe is limited. However there are already 100s of buildings in Japan which have had POF networks installed over the past few years. Costs of GOF are also currently falling, and it will take time for POF to reach the critical mass of several 100,000 km when its true cost advantages will emerge. But when you take into account the ease of installation, lower cost connectors and lower maintenance costs, then the system cost of POF will probably be about 20 percent lower and in line with copper.

Step Index (SI) POF is already commercially available from three manufacturers in Japan (Mitsubishi Rayon, Toray and Asahi Chemical) as well as Digital Optronics in the US. Graded Index (GRIN) POF is available from Asahi Glass Lucina division in Japan and OFS in the US, and will shortly be available from Nexans in Europe.

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