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Brighten up -- it's a new plastic optical fibre technology

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Organic doped pre-forms to be drawn into fibres. © LUCEAT

(PhysOrg.com) -- It may look like little more than fishing line, but plastic optical fibre or POF promises to revolutionise high-speed last-mile communications networks. Its evolution is being aided by groundbreaking research in Europe.

Plastic optical fibre (POF) for data transmission is often described as the “consumer” version of glass optical fibre, the kind that makes up the long-distance trunk routes of telecommunications networks. Flexible plastic fibres, with a core diameter of 1mm and made from polymethyl methacrylate (PMMA), are cheap to produce, easy to install and transmit light in the visible range as opposed to infrared, making maintenance easier and safer. But those properties typically come at the expense of lower bandwidth and high attenuation, restricting their use to sending data over short distances at relatively low speeds.

As a result, POF networks have mostly been used as an alternative to copper wires for short-distance - or so-called last-mile - data transmission. In offices and homes, POF has become a popular alternative for setting up local area networks (LANs), while in cars plastic fibres have replaced copper for sending video signals to onboard entertainment systems or obtaining data from sensors. That, however, is but a fraction of the potential uses for the technology.

Groundbreaking research by a team of European scientists working in the EU-funded POLYCOM project has helped put POF on track for use in optical computing, ultra-high-speed LANs, new sensing devices and even clothing that lights up for safety or simply fashion.

“The range of applications for POF and the optical technology that underlies it is extensive... and its development beyond the current state of the art could benefit a wide range of sectors over the coming years,” explains Guglielmo Lanzani, a researcher at Milan Technical University and coordinator of POLYCOM.

World first in all-optical, high-speed switching

One of the key achievements of the POLYCOM team is the world’s first all-optical high-speed switch for POF networks, a crucial step towards blisteringly fast optical data transmission. The technique, tested at the 520-nanometer wavelength (at which light appears green), involves using two beams of light from a single pulsed laser source in a special plastic optical fibre, the physical properties of which have been chemically modified, or doped, with photoactive polymers to change the way it transmits photons.

By overlapping the light pulses in space and time it is possible to use one light pulse to cancel out the other, thus switching it from on to off and transmitting a data signal. And because of the specific properties of the doped POF the cancellation of the light is reversed within only a few hundred femtoseconds (one femtosecond is one billionth of one millionth of a second).

“Not only will this increase data transmission rates in POF networks, but it could be used for time division multiplexing (TDM) to increase the bandwidth of optical networks beyond what is possible with current wavelength division multiplexing (WDM) techniques,” Lanzani says.

Whereas WDM uses light pulses of different colours to create different channels and therefore carry more data along a single fibre, TDM, as its name suggests, separates the pulses by time, allowing two or more signals to be carried as asynchronous sub-channels within a single fibre.

With bandwidth demands set to continue increasing, separating the signals at the transmission end and sorting them at the receiving end will require switching at rates that only an all-optical - as opposed to an optical-electronic solution - will be able to achieve.

The doped-POF used by the POLYCOM team for the all-optical switch is a polyfluorene called F8BT, one of several different materials studied by the group to test their optical properties. Several new types of doped POF were also developed by the researchers.

“In all, we developed and tested five or six new generations of materials, using different chemical agents to dope them in order to improve their optical properties and achieve very good dispersion of the doping agent in the polymer in several cases,” Lanzani says. “Each of the materials has different characteristics that may make them suitable for different applications.”

Glow in the dark clubbers?

An offshoot of the research was work on optofluidic channels in which the researchers exploited the optical properties of conjugated polymers in a fluid solution inside a microfluidic channel in order to produce a compact photonic device. Such a device could be used as the basis for a biochip for health applications in which optical sensors could be used to identify bacteria, viruses and even DNA strands in body fluids.

Though a commercial optofluidic device is probably some way off, Lanzani notes that the team's research is likely to feed into a variety of commercial applications over the coming years, particularly as interest grows in the range of uses to which POF can be put.

"The auto industry will continue to demand faster and higher capacity POF networks as cars become more complex, while interest in using POF for LANs and telecommunications is continuing to grow," Lanzani notes.

In addition, some research groups and companies are looking to use POF to create new sensing devices, relying on changes in the way the fibres carry light to measure liquid levels or humidity. And given its low cost and, with the right materials, dazzling luminescent properties, it is also being considered for safety clothing and probably even by clubbers looking to stand out in the crowd!

More information: POLYCOM project -- www.fisi.polimi.it/polycom

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