3-D photonic crystals will revolutionize telecommunications

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Smaller, faster, more efficient: BASF research scientists are helping to revolutionize the future world of telecommunications – with the aid of three-dimensional photonic crystals.

In a three-year project, BASF is researching into the development of these crystals together with partners such as Hanover Laser Center, Thales Aerospace Division, Photon Design Ltd., the Technical University of Denmark and the Ecole Nationale Supérieure des Télécommunications de Bretagne. By the end of 2008, the partners in the "NewTon" project expect to have developed the first functional components of this new technology. The long-term goal is to use three-dimensional photonic crystals as construction elements in telecommunication. Half of the project is being funded by the European Union.

Many times more information can be transmitted by light in the same time as has so far been possible with electricity. This is why telephone conversations, websites, photographs or music, for example, are now increasingly being transmitted in optical fibers. At present, however, this technology still has one drawback at the "network nodes". Indeed, at these nodes the routing of the information to the end-user is still done electrically, because no competitive, compact all-optical routing processor is yet available. This costs time and energy.

This is where the research activities of BASF and its partners come into the picture. They are developing a photonic crystal capable of reflecting only single colors of the white light depending on the observation angle. This phenomenon is known from nature: the splendid, shimmering colors on butterfly wings derive from the properties of photonic crystals.

"A structured three-dimensional photonic crystal could be the key component for a compact optical semiconductor or even for an all-optical routing processor", is the opinion of Dr. Reinhold J. Leyrer who is BASF's project leader in Polymer Research division. "Converting optical signals into electrical signals would then be superfluous". But the scientists first have to develop a stable, structured three-dimensional photonic crystal. And exactly this is the goal of the EU project "NewTon". This kind of basic research projects are especially suited to activate the European scientific competence, in order to strengthen the competitiveness of the whole region and of all involved industrial branches.

The production of these crystals is based on aqueous dispersions, a key competence of BASF. These dispersions contain polymer spherical particles measuring about 200 nanometers which, when the fluid evaporates, are forming a homogeneous protective film as it is expected with the paints. Depending from the chemical structure of the polymer particles they can also arrange themselves into a regular lattice structure, forming a crystal. The challenge facing the Ludwigshafen scientists is to enlarge the polymer particles contained in the dispersions to 1000 nanometers in such a way, that they all have exactly the same diameter. Using emulsion polymerization, they also apply an additional structure measuring less than 20 nanometers onto the polystyrene particles. The intention is to develop the most stable possible, large volume, three-dimensional crystal into which one of the project partners will then introduce the desired structure, the so called "defects".

Light at certain wavelengths then travels along these defects and even around sharp corners: the photonic crystal then acts as a photoconductor and takes the control over the propagation of light. The resulting structured crystal lattice is used in the further manufacturing process as a template, as the scientists call it. The spaces between the polymer spherical particles in the crystal lattice are filled with silicon. The researchers then "burn" the polymer particles out of the lattice. The result: a stable structure that is a mirror image of the original crystal. Crystals of this type could be used as components for an all-optical routing processor in telecommunications.

Manufacturers of components for telecommunication systems would benefit most from the use of photonic crystals. Since the crystals are smaller than electronic components, equipment would also become increasingly smaller and cheaper – while simultaneously offering improved performance. Components and equipment based on photonic crystals would also be more resistant and less vulnerable to electromagnetic radiation.

End users will gain from these advances. In the long term, transmitting information through electrical signals will restrict speed and transmission capacity in telecommunications. The long-term goal is therefore to develop a communications technology based entirely on transmitting information by light waves. The research activities of the "NewTon" project are laying the foundations for this scenario.

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