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1 *Dr. Joachim Storsberg developed a synthetic corneal implant. (© Fraunhofer/Dirk Mahler).*

2 *Synthetic eye prosthesis: the haptic and the edge are modified through layer-by-layer technique.*

3 *Cell culture test: profileration of cells on haptic.*

SYNTHETIC EYE PROSTHESIS

The challenge

For many patients who become blind after an accident or illness, a corneal transplantation could restore the ability to see. Each year, 40,000 people in Europe – in Germany, about 7,000 – await the opportunity to be able to see again, thanks to cornea donors. But donor corneas are not common. Dr. Joachim Storsberg of the Fraunhofer Institute for Applied Polymer Research IAP in Potsdam-Golm developed material and production process for a corneal prosthesis made of plastic. These can help patients who are unable to tolerate donor corneas due to the special circumstances of their disease, or whose donor corneas were likewise destroyed. In recognition of this accomplishment, Dr. Storsberg is being awarded the 2010 Joseph von Fraunhofer Prize.

Design and Development of bioactive Surfaces

An appropriate transparent copolymer is used that exhibits high hydrophobicity and that inhibits cell growth, which is required for the implant to stay clear. The miniscale artificial cornea has to meet almost contradictory specifications: On the one hand, the material should grow firmly together with the cells of the surrounding tissue; on the other hand, no cells should settle in the optical region of the artificial cornea – i.e., the middle – since this would again severely impair the ability to see. And: The outer side of the implant must be able to moisten with tear fluids, otherwise the implant will cloud up on the anterior side. This would consequently require the patient to get a new prosthesis after a relatively brief period of time. The outer side of the implant must also be wettable by lacrimal so that the eyelid can slide across it without friction.

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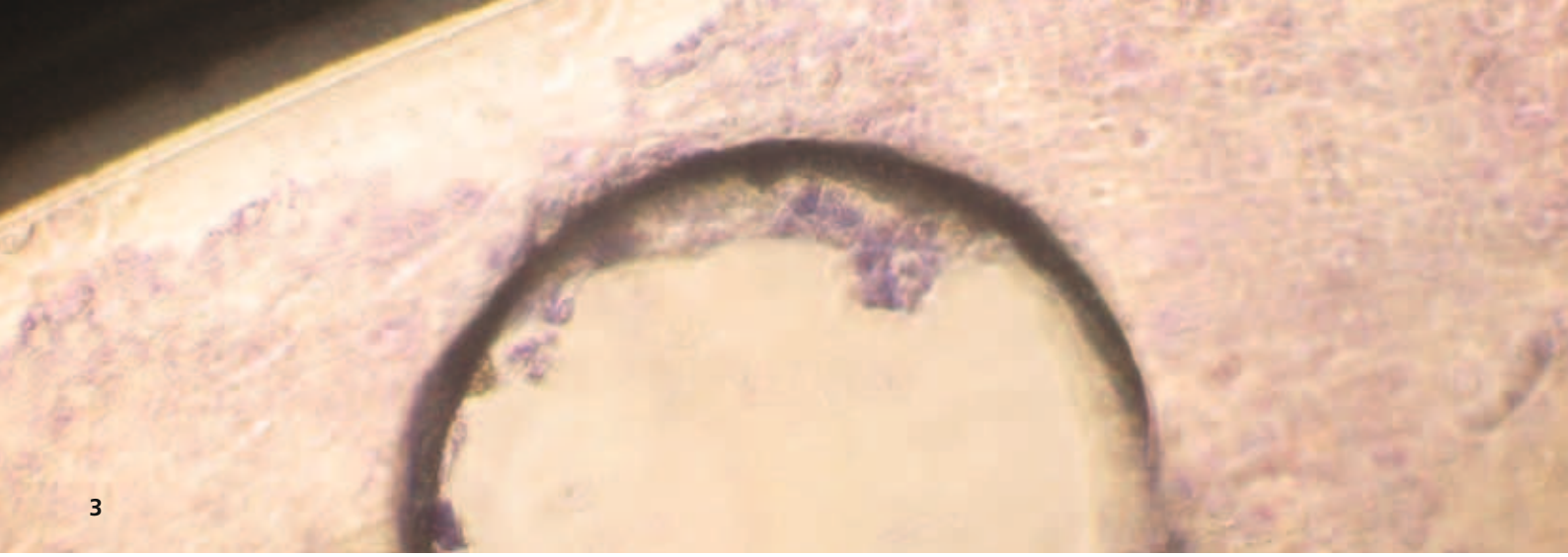
pioneers in polymers



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Dr. Storsberg found the solution with a hydrophobic polymer material. This material has been in use for a long time in ophthalmology, such as for intraocular lenses. In order for it to satisfy the various characteristics required, complex development steps were necessary. The material was thoroughly modified on a polymer-chemical basis, and subsequently retested for public approval.

Selective coating

In order to achieve the desired characteristics, the haptics and the optical part were modified through selective coating.

Using nanotechnological process, the edge of the implant was first coated with various polymers. This was achieved by layer-by-layer deposition of special polycations and polyanions. Then, a special protein was added that contains the specific amino-acid sequence of a growth factor. The surrounding natural cells detect this growth factor, are stimulated to propagate and populate the surface of the corneal margin. Thus, the cells of the surrounding tissue grow with the implant, and the artificial cornea attains stability.

To reach the required hydrophilicity of the outer part of the cornea, a very thin coating is achieved through UV polymerisation of a special monomer. This polymer builds a physically stable, hydrophilic interpenetrating polymer network on that surface.

An interdisciplinary research

The eye prosthesis evolved jointly with physicians and manufacturers in the EU project, »Artificial Cornea«. The interdisciplinary research team needed three years to develop the artificial cornea. In a first step, they sent the chemical-biomimetic coated implant to Dr. Karin Kobuch of the Department of Ophthalmology at the University of Regensburg Medical Center and to the University Hospital rechts der Isar of the Technical University of Munich. The physician examined the artificial corneas in dissected pigs eyes and specialized cell cultures. Eventually, the team under Prof. Dr. Gernot Duncker and Dr. Saadettin Sel of the University Center for Ophthalmology in Halle (Saale) tested the more complex models in rabbits. There, the design was further refined: the optics were made smaller, and the implant haptic enlarged in order to maintain a more stable construction. Miro GmbH manufactured the implant, robin GmbH handled the distribution and sales and supported the specially adapted implantation centers in Europe. By 2009, a prosthesis was already successfully in use; further implantations are anticipated during the first six months of 2010.