



Dr. Friedrich-Karl Bruder develops materials for DVDs and holo-disks

# Master of birefringence



*Many scientists spend their time researching problems that may appear of little practical relevance to the layperson. In fact, however, they are working to make our everyday lives easier. Dr. Friedrich-Karl Bruder is one such scientist. For many years now, the work performed by this Bayer physicist has played a key role in enabling the development of all types of modern storage media, from the CD to the holographic disk.*

Physicists are generally considered dry and sometimes a little out of touch. They are widely believed to spend their time holed up in ivory towers, researching obscure subjects. Such scientists may still exist today, but Dr. Friedrich-Karl Bruder is definitely not one of them. He is immersed in researching real-life issues. "I want to use my knowledge to promote the development of products that are of practical use in everyday life," says the 47-year-old physicist from Bayer MaterialScience.

The first few minutes spent with Bruder make it clear that this is not the bookish theoretician of clichés. Wearing a white shirt and dark jeans, Bruder greets us with an open, friendly laugh and chats easily while escorting us from the main gate to his "kingdom" in the Krefeld-Uerdingen Chempark. His work is the direct fulfillment of his aspirations. Bruder's research has had an extensive impact on our everyday lives. After all, the physicist and his team played a decisive role in the development of the CD and DVD. As a laboratory and project manager in the Global Innovation Department of Bayer MaterialScience AG, Polycarbonates Business Unit, Bruder helps develop high-quality plastics for powerful storage media. As a result, we can carry the "Lord of the Rings" film trilogy home on a single silver Blu-ray Disc.

At Bayer in Krefeld, Bruder has spent the past 17 years working together with

chemists and researchers from other disciplines to improve materials for various generations of optical storage media. Their research has yielded improvements such as greater storage capacity, improved optical quality and optimized mechanical and thermal properties. Bruder is meanwhile especially familiar with polycarbonates. This plastic is essential to the popularity of modern storage media. In fact, the Bayer polycarbonate Makrolon® is what CDs and other storage disks are made of.

### When James Bond grinds to a halt

Bruder's office doesn't reveal much about either his work or his personal life. On his desk are several stacks of paper and a laptop. Dark, high bookcases leave no room for decoration, but two framed photos of both his sons are perched on the wide window sill. This suffices for Bruder, who is usually too engrossed in searching for solutions to complex problems to notice the decor anyhow. Birefringence is one of the important phenomena that the physicist focuses on in his work. "To put it simply," he explains, "birefringence refers to the ability of certain materials to split a ray of light into two sub-rays." The silver disks can take on this characteristic while Makrolon® is being processed by means of injection molding. If bire-

fringence is too high, the data can no longer be read correctly. "Thanks to the specification limits in force, virtually no one has had to cope with the results of such a disaster," says Bruder. CD and DVD players would get stuck, loudspeakers would malfunction and instead of watching James Bond in action, the only thing visible on the screen would be blocks. "The material must therefore be formulated to keep birefringence as low as possible," summarizes Bruder.

In order to create the perfect material, he and his team develop methods enabling them to predict if and how the molecule structure will change during the injection molding procedure and what degree of birefringence can be expected as a result. The length of the polymer chains and their spatial structure influence the plastic's flow properties. "Our findings serve as valuable instructions for chemists when

Practical physicist: Dr. Friedrich-Karl Bruder (large photo) is a practical man. "It makes me satisfied when the products in which I played a hand work properly in daily life." Together with chemists and research scientists from other disciplines, he and his team (photo right) at Bayer MaterialScience work on phenomena and materials for new storage media.





Scientific curiosity: even as a young boy, Dr. Friedrich-Karl Bruder wanted to know "how the world works." In the laboratories at Bayer MaterialScience, he still investigates complex phenomena such as light refraction even today, and is also involved in developing new materials.

formulating their materials," explains the physicist.

### The Big Bang and grandpa's defective TV

Bruder speaks quietly, reticently, but the pace of his words increases when he talks about his work. A slight accent betrays his origins. Bruder's childhood and youth spent in Alpirsbach in the German region of Swabia now seem like something from a bygone era in comparison to his current work. Like everywhere else in Germany in the 1960s and 1970s, black vinyl disks were revolving on large turntables, offices were equipped with typewriters and documents were stored in gray binders and heavy file boxes. Nonetheless, the world supplied enough material to satisfy young Friedrich-Karl Bruder's interest in complex interrelations. He disassembled his grandfather's defective television and read books about the Big Bang and other physical phenomenon in his leisure time. "I wanted to learn how the world works," he explains.

In school, he was better at physics, chemistry and mathematics than at German and history. "The natural sciences deliver hard facts – what is true and what is false. Hypotheses can be clearly proved or disproved by experiments," he says in explaining the passion that ultimately led him to begin studying physics at the University of Freiburg in 1982. Although he barely even noticed the introduction of the music CD (Bayer

played a key role in its development) in that same year, Bruder did experience the information technology revolution firsthand during his university studies. Bruder recalls punch cards and the feats of endurance he and his fellow students had to undertake when the institute's only mainframe computer crashed yet again: "We had to insert about 40 diskettes in order to boot it up again."

Physical phenomena interested him even more than new technology, however. After the abstract contents of the first stage of his university studies, Bruder decided to focus on polymer physics. "I was attracted by the interdisciplinary cooperation with the field of chemistry," says Bruder, explaining one of the reasons for his decision. Bruder and his fellow students were fasci-

nated by a range of questions: How can amorphous or unordered molecule systems be explained? How does molecular structure affect material properties? What methods can be used to predict processing characteristics? Which models are suitable for taking the requirements for the end product into account even during the material development stage? He graduated summa cum laude with a doctorate in 1992 and applied to large corporations and small and mid-sized businesses throughout Germany. Bruder's skill was soon augmented by a little good fortune. He was hired by Bayer AG in the same year, and moved from the Black Forest to the Lower Rhine region together with his wife. He left his old record player behind in southern Germany, replacing it with his first CD player in the new apartment in Krefeld.

### Physics, rock 'n' roll and some Makrolon® in between

"The open, friendly atmosphere in the Rhineland made it easy for us to adapt to our new home. Rock 'n' roll dancing, our hobby at the time, made it easy for us to meet new people as well," says the physicist. His career at Bayer also got off to a smooth start in Krefeld-Uerdingen. Polycarbonate, the material for CDs, was already being produced there. In a later phase, when other plastics with better optical properties were attempting to push onto the market, Bruder was able

Award: Ian Paterson, then member of the Board of Management of Bayer MaterialScience, and Dr. Hartmut Löwer (photo below, left and right) present Dr. Friedrich-Karl Bruder (center) with the Advanced Fellow Award 2007 for special achievements in the development of new materials. One of Bruder's main research subjects was polycarbonate and its properties (photo right).



to use a physical model to prove that polycarbonate as a chain molecule, i.e. in polymer format, offered a much better combination of optical and mechanical qualities for this application during injection molding of disks. As a result, Makrolon® was able to maintain its status as the most popular CD material.

Bruder played a part in the development of the DVD right from the start. Because the individual disks are only half as thick as a CD, the manufacturing process for DVDs required a more complex injection molding procedure. Despite the difficulties, he and his colleagues were successful. Makrolon® was able to prove its worth for use in DVDs as well. "We developed an especially fluid Makrolon with a birefringence level inside the required limits," explains Bruder.

The Bayer researcher has a close relationship to DVDs in his private life as well. His home on the outskirts of Krefeld houses the collection of some 250 movies that he has amassed since the introduction of this format twelve years ago. On rainy Sunday afternoons, the whole family shares his passion for cinema. "We've watched Ice Age with the kids at least ten times already," he says with a laugh.

### Curiosity and openness about complex phenomena

The physicist treasures family life above all else, even when it isn't rain-



A break from physics: Dr. Friedrich-Karl Bruder enjoys getting away from his research work and spending time building models or playing table tennis with his sons. Sometimes they even demonstrate the limits of theoretical physics or – like father, like son – point him in the right direction.

ing outside. He relaxes by working in his garden ("I see the results of my work immediately there"), during weekly tennis games with his wife and sons or, when on vacation, by leaving the Lower Rhine region behind and heading for the mountains. Bruder also unwinds from his job by constructing detailed models of cars, ships and airplanes from hundreds of tiny pieces with his ten-year-old son. "I can forget about everything else while we are building models," he says. Perhaps because he knows that all the parts will fit into place without much thought. As a researcher, the many diverse interrelations in polymer physics and the exciting questions they yield will capture his heart and mind again soon enough – at the latest on the next working day.

Right now he is occupied primarily with holographic storage systems. Bruder and his colleagues are at the forefront of research on this powerful storage media of the future. In cooperation with U.S. company InPhase, they developed the holo-disk offering far greater storage capacity than all other formats (see also *research* 18, page 14: "Long life for data"). The challenge facing the material researchers: "The initial focus was not just the design of the base material, but the storage media itself," explains the Bayer researcher. That means finding a material that would allow data to be inscribed into the chemical structure in three-dimensional format via laser beam. Bruder is also interested in correlations between

structure and characteristics. However, the goal is now to develop new experimental methods for measuring and evaluating additional characteristics such as light sensitivity or the size of storage capacity. "Holography has taken us into all-new territory," he says. The perfect adventure for a dyed-in-the-wool scientist, in other words. "Researchers need to be curious and have an open mind in order to discover how complicated things work." When they are able to do that, they know that their work is a success. "It gives me a sense of satisfaction when the products I have helped to develop function as they should in everyday life," says Bruder.

In early November, Bruder received the Innovation Prize from the German state of North-Rhine Westphalia in recognition of his outstanding development achievements.



[www.research.bayer.com/edition\\_18/Holography.aspx](http://www.research.bayer.com/edition_18/Holography.aspx)  
Additional information on holographic data storage technology is available here.