Nitto Denko Group: focusing on "Green, Clean and Fine" to research and develop products that are friendly to the global environment and contribute to human health and amenity

Development of Gecko Tape Using Carbon Nanotubes

Creating a new adhesive technology based on biomimicry research

In the last few years, attention has focused on biomimicry technology, which applies technologies inspired by the natural world. The gecko tape which Nitto Denko has developed jointly with Professor Yoshikazu Nakayama of Osaka University is one example.

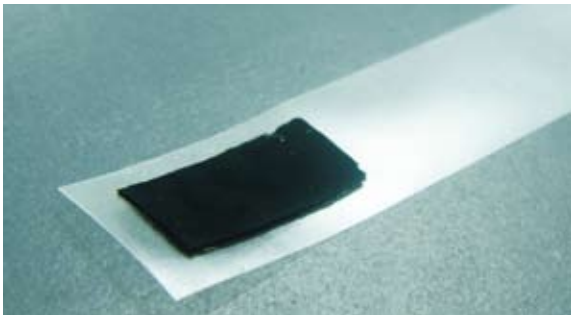

Gecko

The gecko is a reptile able to crawl without difficulty even up and down window panes of completely smooth glass despite having no suction cups or sticky substance on its feet. Its secret lies in the fine hairs which grow abundantly on its toepads. Each of these hairs establishes close contact with the surface of the wall or ceiling, even where it is uneven. By thus eliminating the intervening space, the hairs produce a high adhesive strength based on intermolecular force, which can be easily broken by altering the angle between the hair and the wall surface, allowing the gecko to walk across the wall.

Nitto Denko has reproduced this gecko hair artificially using carbon nanotubes to create a tape which uses a mechanism quite different to that of conventional adhesives to provide strong adhesion and easy de-adhesion. The aim is commercialization of an adhesive product which avoids soiling the adherend and provides high adhesive strength and resistance to high temperatures.


Toepads of a gecko


Magnification of toepads shows an abundant growth of fine hairs


Gecko tape; black area is 'hair' made of carbon nanotubes.

TOPICS

Gecko tape featured in 'Smart-Eco' exhibition on natural technologies and sustainable lifestyles

Nitto Denko also participated in an exhibition held at the National Museum of Nature and Science at Ueno in Tokyo from October 26, 2010, to February 6, 2011, exploring natural technologies, which imitate nature, and human lifestyles.

The exhibition focused on natural technologies, which are inspired by various insights from the world of nature and living creatures, and sustainable lifestyles, which reduce the burden on the environment. The gecko tape outlined above was included in the exhibition and attracted fascinated attention from many visitors, especially elementary school children.

Further Improvement of New Organic Polymer-type Hologram Display and Renewed Publication in *Nature*

Using our novel organic photorefractive material, which has the world's highest level of diffraction efficiency and a high writing speed, US-based Nitto Denko Technical Corporation (NDT) has succeeded in developing an improved rewritable hologram display with outstanding image persistency. The project was carried out in collaboration with a research group led by Professor Nasser Peyghambarian of the University of Arizona.

In February 2008, detailed presentations of the related system, methods, and other aspects were published in several scientific journals including *Nature* – one of the world's leading scientific journals – along with various news media including CNN. Following further progress and improvements, another paper was published in the November 2010 issue of *Nature*, attracting further interest.

1. Features of the Technology

(1) Refreshable three-dimensional moving images through improved rewritability

The new type of hologram is a three-dimensional image recorded on a film or other medium in three-dimensional form. Holograms are already in use on credit cards, bank notes, etc. to prevent counterfeiting. When viewed from different angles, the image pattern undergoes subtle changes enabling the human eye to perceive it as a three-dimensional image (Figure 1).

Compared to other three-dimensional image display methods, the hologram gives a more natural effect and is less fatiguing on the human eye.

However, conventional hologram recording materials were not rewritable and were therefore unable to reproduce continuous moving images. NDT therefore worked on the development of an organic polymer system which could be manufactured at low cost and coated easily onto a glass plate or plastic substrate. Then, in collaboration with the University of Arizona, NDT focused on the photorefractive method and succeeded in making the image refreshable by enhancing the material and optimizing fabrication.

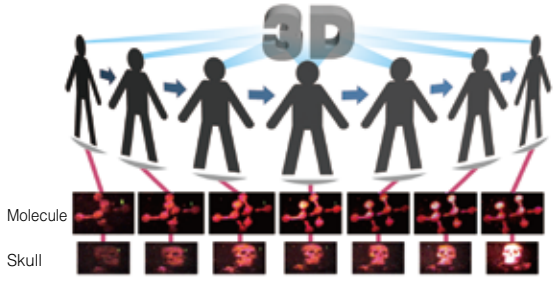
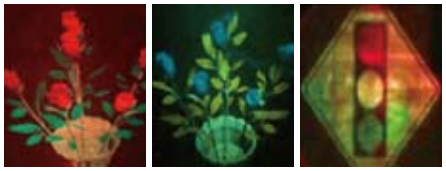


Figure 1: Rewritable hologram image created using the newly developed system. By combining images viewed from different angles, the image is made to appear as 3D.

Since 2008, the refreshing speed in particular has been drastically increased; for instance, what used to take three minutes on a 6-inch by 6-inch display can now be rewritten in a matter of seconds. Further studies are now in progress aiming to improve speed by more than a factor of ten to match the video rate.

(2) Enabling color holograms

The previous photorefractive method showed red images only. However, the present project succeeded in realizing full color by developing new material chemical components and introducing special device structures.



Red roses Blue roses Traffic light

Figure 2: Color images. Various colors can now be displayed.

(3) The world's largest display size

The display size as of 2008 was limited to 6" x 4". By utilizing our technological strength and polymer processing technology know-how, the Nitto Denko Group has successfully developed a flawless, large-sized three-dimensional holographic display with good uniformity. The display size of 12" x 12" (Figure 3), an enlargement of nearly ten times, is the world's biggest rewritable 3D photopolymer material-based sample to date. The Nitto Denko Group is pursuing R&D efforts to achieve a further tenfold increase in speed with the aim of equaling video refreshing speed.

Figure 3: Size of newly developed display medium (yellow section)

(4) Enables three-dimensional images not only in the horizontal but also the vertical plane

Almost all existing three-dimensional display devices, such as three-dimensional televisions, employ a display method wherein two slightly different versions of an image are separately projected in a stripe pattern for the left and right human eyes. Human eyes

can recognize the “makebelieve” three-dimensional display only when the projected image is viewed horizontally. When the human head moves vertically, the projection cannot be perceived as three-dimensional. With the newly developed display method, the output can be viewed from both horizontal and vertical angles, which gives a more natural image perception. Unlike other conventional methods, the new method projects an image that human eyes can perceive as three-dimensional even when they are looking up from a lying position. The novel display technology, which is known as a full parallax, may lead to the realization of a further enhanced state of three-dimensional imaging in the future.

2. Future Prospects for Development

The newly developed photorefractive three-dimensional image method can be applied in areas including image recognition, medical imaging, and optical communication materials. For instance it can be applied to creating three-dimensional maps, three-dimensional rendering of the surgical site during operations, and three-dimensional modeling for mock-up designs for vehicles and machines.

The ultimate goal is a three-dimensional television able to project a three-dimensional image that makes it look as if the object itself is protruding from the screen in front of our eyes. The article in the recent issue of *Nature* also reports the possibility of remote three-dimensional videoconferencing (3D tele-presence). Going forward, efforts will be intensively directed toward development of a range of devices.

Nitto Denko to Develop siRNA Drugs with US Company Quark Pharmaceuticals, Inc.

Aiming for the swift commercialization of drugs for fibrotic diseases

On July 4, 2010, Nitto Denko concluded a contract with US pharmaceutical company Quark Pharmaceuticals, Inc. (Quark) for the development of therapeutic drugs for treating fibrotic diseases such as cirrhosis of the liver.

1. Fusion of Global Technologies to Realize New Therapeutic Drugs

siRNA (small interfering RNA) is known to control the expression of target genes using ribonucleic acid (RNA) with specific sequences. When this siRNA is delivered to certain cells, it inhibits the production of molecules that cause disease. As such it is receiving much attention as a revolutionary new way of potentially treating diseases that up until now have been said to be incurable.

Since 2008, Nitto Denko has been working with Professor Yoshiro Niitsu of Sapporo Medical University, who developed technology for treating fibrotic diseases such as liver cirrhosis, to design drugs, verify therapeutic efficacy and clarify the therapeutic mechanism.

The company entered into the agreement with Quark, which has a proven track record in siRNA drug development, in order to push ahead with the development of therapeutic drugs for treating fibrotic diseases such as liver cirrhosis.

By combining our proprietary drug delivery technology and fibrotic disease treatment concept with Quark’s hands-on know-how, Nitto Denko Group hopes to file an Investigational New Drug (IND) application with the US Food and Drug Administration (FDA) by 2012 and to eventually develop treatments to help the many people throughout the world who suffer from these conditions.

2. About Quark Pharmaceuticals, Inc.

Established in 1993 and with its headquarters in Fremont, California, Quark has a research and development facility in Israel and a staff of approximately 100.

During its early years it accumulated an extensive range of genetic information concerning a wide range of conditions and during the 2000s commenced drug discovery activities. The company currently has five clinical trials in the pipeline for conditions such as age-related macular degeneration, diabetic macular edema and acute renal failure, and is one of the world’s leading companies in the field of siRNA drug development.

The project team consisting of Prof. Niitsu and staff from Nitto Denko Group and Quark Pharmaceuticals, Inc.