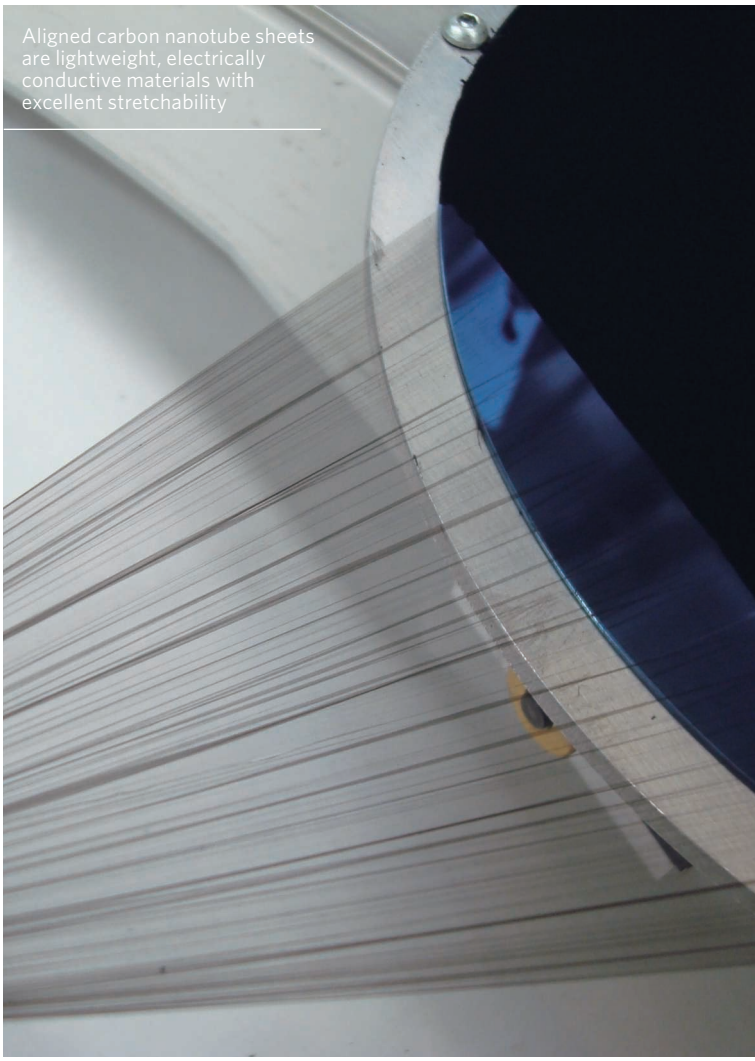
Widening the scope of carbon nanotubes

TAIYO NIPPON SANSO CORPORATION is well established in the energy industry. Now, innovation in carbon nanotubes is leading its charge into novel applications across a range of markets.



Aligned carbon nanotube sheets are lightweight, electrically conductive materials with excellent stretchability

Operating in more than 20 countries through industrial gas production facilities and subsidiaries, Taiyo Nippon Sanso Corporation is leveraging its global reach and technologies to venture into new market areas.

Since 2002, the company has strengthened its technical development to commercialize carbon nanotubes (CNT) for wide-ranging applications in the electronics, automotive and other industries.

Taiyo Nippon Sanso is the leading provider of industrial gases in Japan with a 40% share of the domestic market

THIS CONCEPT OF 'LESS IS MORE' IS HELPING THE COMPANY REACH ITS GOALS

in 2016: the company ranked first for core products such as oxygen, nitrogen, argon, carbon dioxide and helium, and second for acetylene. Internationally, it is well known for its semiconductor manufacturing equipment and systems, particularly in Taiwan, South Korea and the United States.

In recent years, the company has diversified its product line-up to include hydrogen filling stations, liquid nitrogen-based refrigeration systems and cryogenic technologies, for example, for the storage of induced pluripotent stem (iPS) cells. The company also now offers its own line of innovative CNT materials.

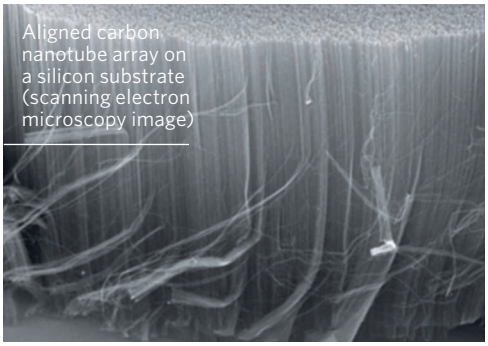
Thinking laterally for hot new products

Based on its expertise in handling gas products, Taiyo Nippon Sanso's research and development laboratory in Yamanashi, central Japan, has developed a high-performing, heat-resistant material that consists of a synthetic resin (polytetrafluoroethylene or PTFE — a familiar product is Teflon®) mixed with a minimal amount (just 0.05%) of CNT.

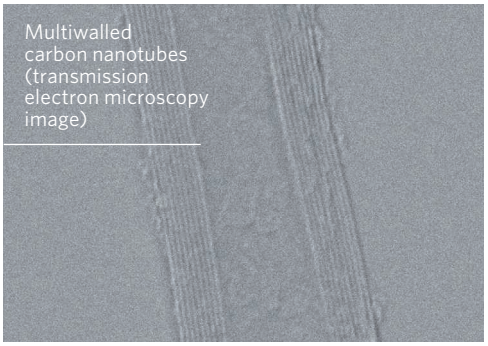
Known as 'fluorinated resin with CNT', this material achieved a thermal conductivity 2.6 times greater than that of PTFE alone. Electrical conductivity was shown to be on par with PTFE containing 3% of conventional carbon black, used previously for automotive parts and other electrical components. Moreover, the CNT version was found to help prevent build-up of static electricity.

This concept of 'less is more' is helping the company reach its goals. "By minimizing the amount of CNT needed to achieve high performance, we have met our target of producing 10 tonnes of this material annually," says Toru Sakai, project manager of Taiyo Nippon Sanso's research and development planning division. "Applications so far include semiconductors, auto parts, packaging materials and pipelines for transporting chemical liquids."

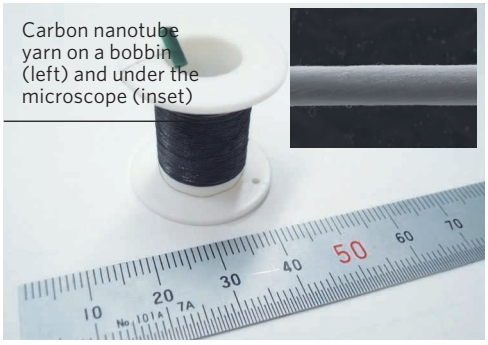
The ability to tolerate solvents is important. Even when the material was immersed in hydrochloric acid aqueous solution for 24 hours, researchers at the Yamanashi laboratory found that the material remained intact: the metal and carbon components of the material were below the detection limit. Development manager Junichirou Asai says: "This is an important advantage, as it means that it can be used in cleaning equipment or in other industrial procedures where cleanliness takes precedence."



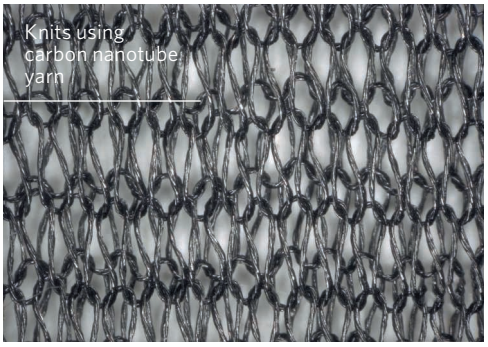
Aligned carbon nanotube array on a silicon substrate (scanning electron microscopy image)



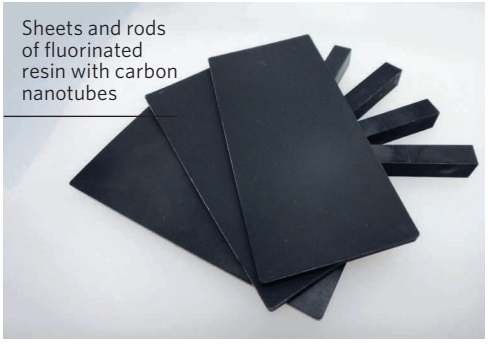
Multiwalled carbon nanotubes (transmission electron microscopy image)



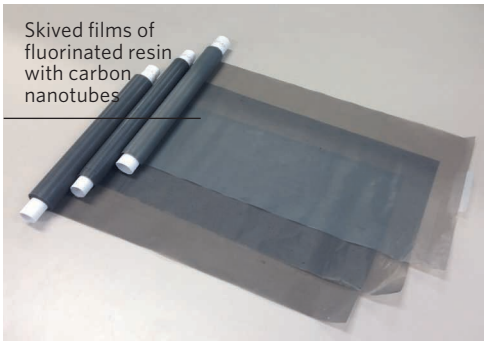
Carbon nanotube yarn on a bobbin (left) and under the microscope (inset)



Knits using carbon nanotube yarn



Sheets and rods of fluorinated resin with carbon nanotubes



Skived films of fluorinated resin with carbon nanotubes

The new material can take many forms and Taiyo Nippon Sanso currently supplies fluorinated resin with CNT as sheets, rods, tubular sleeves and skived films (used, for example, in adhesive tapes). Each shape could in future be tailored to meet the requirements of different electrical and mechanical applications. Food and biomedical applications however will require further testing.

Adding a new string to their bow

The company's nanotech innovations go still further — and finer. "We are particularly proud of our development of CNT yarn, an ultralight, durable and highly flexible thread made of 100% CNT," says Sakai. "We have already fabricated samples such as grid meshes and knitted fabrics with this yarn, which we expect will respond to new user needs."

As the crowning achievement of five years of developmental research, the CNT yarn is now at the cusp of full-scale marketability. Sakai explains that the production process involved two stages.

First, using Taiyo Nippon Sanso's proprietary technologies, carbon nanotubes with exceptionally high purity (over 99.5% CNT) and with a diameter of between 5 to 20 nm were aligned and placed as a series of layers on to a silicon substrate. These multiple layers formed a thin sheet of CNTs, known as buckypaper after the discovery of buckminsterfullerene by Nobel laureates, Robert Curl, Harold Kroto and Richard Smalley in 1985. These aligned sheets are stretchable — or what is known in the industry as 'drawable'. With a thickness ranging from 10 to 30 µm, these drawable CNTs are lightweight, electrically conductive materials.

Second, working with associate company Murata Machinery Ltd, a leading textile machinery manufacturer with its headquarters in Kyoto, the drawable CNTs were spun into spools of extremely thin CNT threads. Now available are threads of several metres in length with a diameter between 10 to 50 µm. Murata Machinery's expertise in spun-yarn technology was indispensable to producing such fine thread. The CNT yarn can achieve a conductivity of 5×10^4 siemens per metre. In future, meeting industrial requirements will require optimizing not only the length and thickness but the uniform quality of the threads. "As our CNT yarn can be fabricated into other materials, within the next few years it may be used, for example, in smart clothing or in lightweight wire harnesses," says Sakai.

An international showcase

Taiyo Nippon Sanso will showcase its CNT products at Nanotech 2018, the world's largest event for nanotechnologies, to be held at the Tokyo International Exhibition Center (Tokyo Big Sight) on 14–16 February 2018, with an anticipated 50,000 visitors.

"We look forward to engaging with representatives from the semiconductor, automobile, electronics and chemical industries, and we also welcome enquiries from all those interested in our products," says Sakai. ■

CNT-uni

CNT-uni represents Taiyo Nippon Sanso's "Unique" & "Uniform" CNT product series

TAIYO NIPPON SANSO
The Gas Professionals

www.tn-sanso.co.jp/en
www.ostec-tec.info/coe-osaka/en/cnt.html