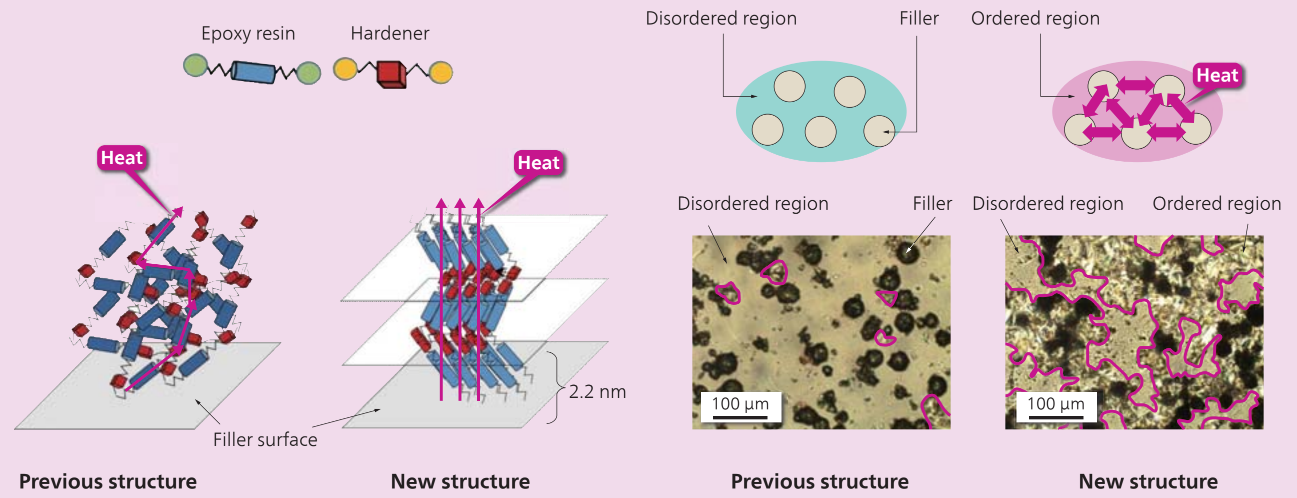
High Functional Materials & Components



1 Filler/resin interface structure of new composite (left) and structure around filler (right)

1 High-thermal-conductivity Composite Insulator with Reduced Thermal Resistance at Filler/Resin Interface

This high-thermal-conductivity composite consists of epoxy resin and ceramic powder (filler) and is used for insulating adhesive sheets, molding materials, and other insulators in electrical and electronic equipment. The smaller size and higher output densities of electrical and electronic equipment require these insulators to have high thermal conductivity.

Hitachi has been researching composites formed from ceramic powder and an epoxy resin that exhibits high thermal conductivity due to a structure that self-organizes at a molecular level during hardening. When this self-organizing resin has been mixed with nitride filler in the past, it has failed to exhibit sufficient thermal conductivity because of the thermal resistance resulting from the resin structure becoming disordered at the filler interface.

In response, Hitachi has developed a technique that uses a filler surface treatment to maintain an ordered resin structure at the interface. Oxidizing the filler surface, controls the surface free energy and gives the hardened resin an ordered structure at the filler interface, with a period of 2.2 nm in the direction roughly vertical to the interface. Furthermore, the ordered structure is formed over a wide region so as to fill up the space between filler particles. This has succeeded in reducing the thermal resistance at the filler/resin interface and increasing the thermal conductivity of the high-thermal-conductivity composite.

2 High-toughness Nano-composite Resin for Molding Machines and its Associated Design and Analysis Techniques

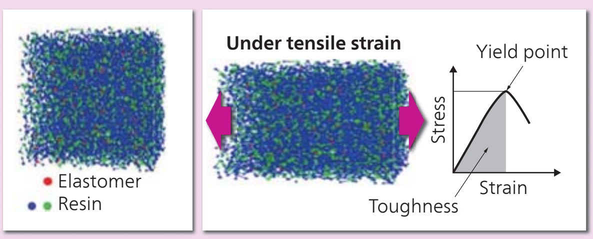
Hitachi has developed a nano-composite resin for molding machines that has excellent fracture toughness (an indicator of resistance to cracking).

Fine elastomer particles were chosen as the toughening agent. Hitachi also made full use of the following computational methods in the development process.

(1) The molecular orbital method was used to calculate the interactions between the nanoparticles and resin.

(2) The calculated interactions were used in coarse-grained molecular dynamics.

(3) The stress-strain characteristics under tensile strain were obtained using (2) and the fracture toughness was predicted.



2 Computational model for coarse-grained molecular dynamics (left) and toughness calculation method (right)

This calculation found that the fracture toughness with an elastomer particle size of 100 nm was 50% higher than the resin on its own. Fracture testing was then conducted on a test piece made of epoxy resin mixed with 100-nm elastomer particles to confirm that the experiment agreed with the calculated prediction.

The new technology represents a combination of coupled micro-macro computational methods with experimental material testing with the aim of improving molding machine performance. The molecular orbital method was developed by Hitachi, and the coarse-grained molecular dynamics calculation was performed using the OCTA high functional materials design platform.

3 Visual Connection Identifier Module for LC Duplex Connectors

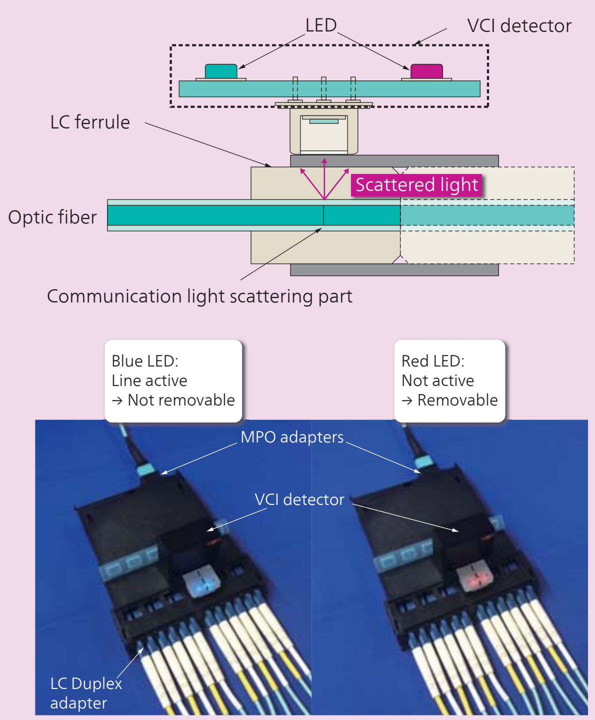
The rapid increase in transmission bandwidth means that work on optical cabling needs to be done efficiently.

There is a risk of major losses if an optical connector carrying heavy communications traffic is inadvertently unplugged when modifying or uninstalling communication cabling. The visual connection identifier module provides a simple visual indication of whether an optic fiber is in use, and has gained an excellent reputation as a product that enables the safe unplugging of connectors. Hitachi has previously released visual connection identifier modules for use with square connectors (SCs), local connectors (LCs), and Simplex optical connectors.

Now, Hitachi has developed an additional module for use with the LC Duplex optical connectors that are widely used outside Japan. Housed in a compact case, the module has six LC Duplex adapters (12 cores) on the front and a 12-core multiple-fiber push-on/pull-off (MPO) adapter on the rear. The small amount of scattered signal light that leaks from the LC ferrule is detected by a photodetector, and light-emitting diodes (LEDs) are used to provide a simple visual indication of the presence or absence of an optical signal (a blue LED illuminates to indicate a signal, and a red LED illuminates to indicate no signal). The photodetector has two sensors to enable simultaneous detection of two cores.

In the future, Hitachi intends to expand the product range and market the product widely in Japan and elsewhere.

(Hitachi Metals, Ltd.)



VCI: visual connection identifier

3 Principle of operation and product photograph of visual connection identifier module for LC Duplex connectors

4 Rare Earth Magnet Recycling Technique Using Carbothermal Reduction

The manufacturing process for NEOMAX* rare earth magnets, composed of neodymium (Nd), iron (Fe), and boron (B), produces sludge as a by-product. Since this sludge contains valuable rare earth elements, reusing rather than disposing of these presents an important challenge for the efficient use of resources. While the conventional method for extracting rare earth elements from sludge involves dissolving in acid and precipitation, this imposes a significant load on the natural environment because of the large amount of iron oxide residue that results.

Hitachi's new technique, however, dramatically reduces the use of acids and alkalis and reduces this environmental load by applying the carbothermal reduction method used in the steel industry to burned sludge, from which the rare earth elements can be recovered as slag and iron elements can be recovered as valuable pig iron. Furthermore, in experimental testing, this method achieved a higher yield of rare earth elements than the existing method.

Full-scale production using the new technology is scheduled to commence in April 2015.

(Hitachi Metals, Ltd.)

* NEOMAX is a trademark of Hitachi Metals, Ltd.

4 Material produced by carbothermal reduction of magnet sludge

5 Stainless steel piston rings (top) and stainless steel piston ring wire (bottom)

6 Thermal Conductive Sheet with Vertically Aligned Graphite

The higher heating density resulting from the smaller size and greater integration of semiconductor packages has required the electronic device field to focus on cooling techniques that can limit rises in device temperature. Thermal conductive sheets are used to increase the efficiency of heat transfer from heat source to heat sink and therefore require high thermal conductivity across the thickness of the sheet and the flexibility to be compliant with the warpages between components. As the trade-off between these two properties makes this a very difficult criterion to satisfy in the same material, Hitachi has utilized composites and the control of material structure to achieve both.

The new thermal conductive sheet combines a technique for aligning anisotropic fillers with graphite and soft resin to achieve both high thermal conductivity across the thickness of the sheet (90 W/mK) and flexibility. The use of this new material is expected to assist with heat dissipation design and enable electronic device to be made compact, with longer life, quieter operation, fewer components, and saving energy.

It is available in a range of variations with enhanced functions, including a reusable type, high-strength type, and high-compression type. In the future, Hitachi plans to market it for a wide variety of applications in Japan and elsewhere.

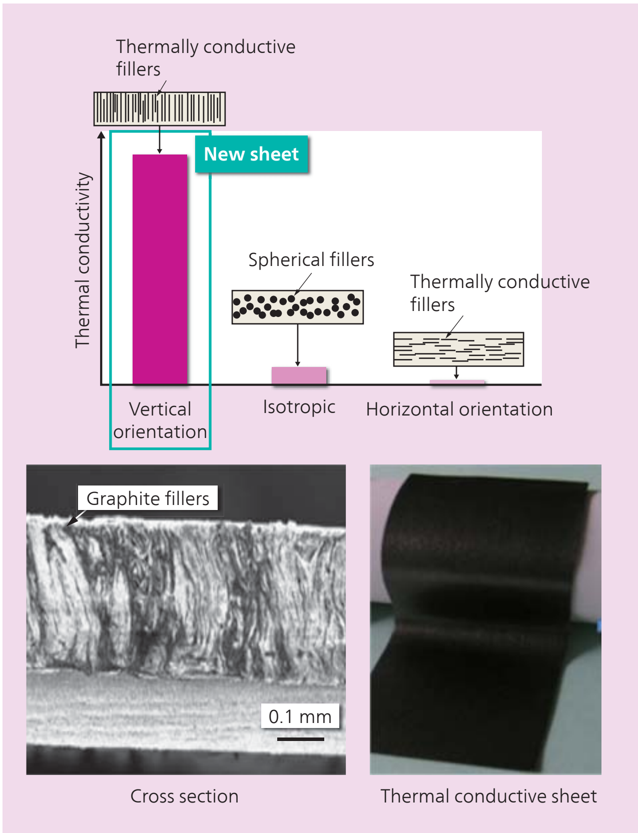
(Hitachi Chemical Co., Ltd.)

5 Shaped Wire Material for Precision Piston Rings

Piston rings are key components of automotive engines, providing the seal that converts the energy of combustion into motive power. Because they are in direct contact with hot combustion gases and in constant sliding motion against the cylinder, the requirements for piston ring materials include resistance to both heat and wear. Meanwhile, with steps being taken to deal with environmental problems and save on the use of resources, the trend in vehicle engines is toward downsizing and the adoption of turbocharged direct injection to reduce emissions and increase output. This has led to a growing need for higher strength and higher shape accuracy in piston rings.

Hitachi Metals' martensitic stainless steel alloys containing 8 to 17% chromium (Cr) were developed as a specialty steel grade for use in piston rings. Featuring a strength-to-weight ratio significantly higher than conventional castings, these alloys have now entered mass production. The demand for increasingly complex cross sections with tighter tolerances means that shape accuracy in the order of microns is required for "near-net" wire. To achieve this, Hitachi employs a precision shaped rolling technique that helps reduce machining times for piston ring manufacturers.

(Hitachi Metals, Ltd.)



6 Concept of structure control for sheet with vertically aligned graphite (top), and a cross section and appearance of the sheet (bottom)