High Functional Material

1 Silicon Nitride Circuit Board for Power Modules

While past practice has been to use alumina and aluminum nitride for the insulated substrate used in the power modules of automobiles, new forms of energy, industrial equipment, and other such applications, silicon nitride substrates are increasingly being adopted because of their excellent material strength, thermal conductivity, and insulation.

In the past, commercial-scale production of silicon nitride substrates by Hitachi Metals, Ltd. has largely been of the insulated substrates themselves. Recently, however, Hitachi Metals has embarked on the full-scale production of silicon nitride substrates for power modules that are composed of a silicon nitride insulated substrate brazed to copper sheet.

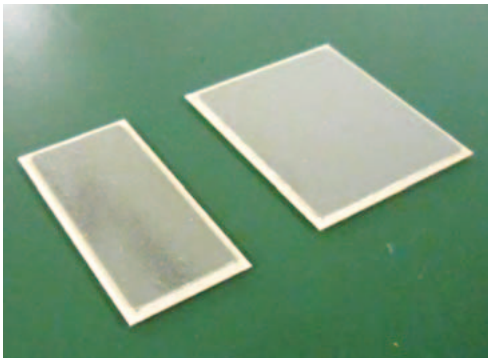
Hitachi Metals already has the materials used in a silicon nitride circuit board (the silicon nitride substrate and the brazing material and copper sheet), and is able to satisfy a wide variety of customer requirements. A newly developed silicon nitride substrate with high thermal conductivity (130 W/m•K) is also available.

There is a trend toward the use of thicker copper (0.6 mm or more) to enhance the heat dissipation of circuit boards for power modules. Hitachi Metals has come up with a wide product range to coincide with silicon nitride circuit boards for power modules entering full-scale production. Hitachi Metals has also started to offer surface treatment of copper circuit in the form of plating with nickel (Ni), silver (Ag), etc., and the intention is to expand the options for material characteristics, copper thickness, and copper circuit patterns in the future.
(Hitachi Metals, Ltd.)

2 Electric Motor Operated Segment Ball Valve with Variable Open/Close Time

Valve open/close times in process piping have a direct impact on productivity, with the time taken for valves to open or close needing to be appropriate. One example is the need to close fluid pipe valves more quickly to avoid the water hammer effect and minimize as much as possible its effect on productivity. Another example is fluid weighing applications where the valves need to open slowly but close rapidly so as to avoid oversupply.

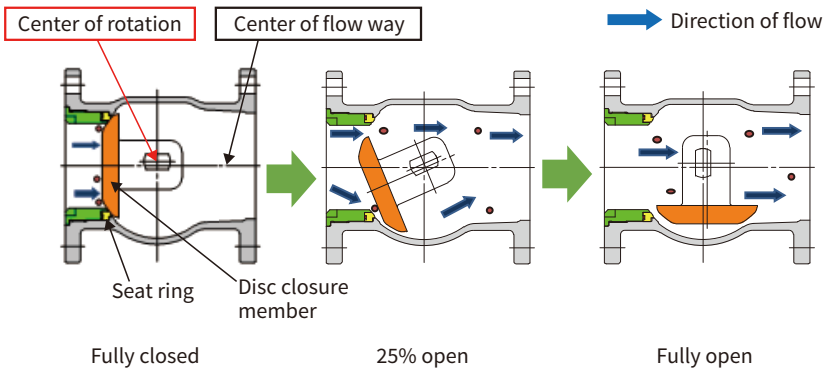
In response to these requirements, Hitachi Metals has developed an electric motor operated segment ball valve that is able to open and close rapidly with a variable open/close time. The stability of the valve's



Material	Parameter	Units	Standard values
Silicon nitride	Thickness	mm	0.25, 0.32
	Thermal conductivity	W/m·K	90,130
	Fracture toughness	$MPa \cdot m^{1/2}$	6.5
	Flexural strength	MPa	700–800
Copper	Thickness	mm	0.6–0.8 (in mass production) >0.8 (newly developed)

1 Silicon nitride circuit board (left) and specifications of silicon nitride substrates and copper thickness range (right)

Parameter	Specification
Fluid/gas	Fluid
Valve material	SCS13A
Maximum allowable working pressure	1.4 MPa
Maximum cutoff differential pressure	Type 1: 0.3 MPa Type 2: 0.5 MPa Types 3 & 4: 1.4 MPa
Fluid temperature	5–80°C
Port diameter	100–200 A
Connection type	JIS 10K flange
Operating time	Type 1: 1, 2, 3, or 4 s (optional) Type 2: 2, 4, 6, or 8 s (optional) Type 3: 3, 6, 9, or 12 s (optional) Type 4: 4, 8, 12, or 16 s (optional)
Drive voltage	AC100 V



JIS: Japanese Industrial Standards AC: alternating current

2 Segment ball valve (left), valve specifications (top right), and valve open/close mechanism (bottom right)

operating torque characteristics and the torque characteristics of the electric motor in the actuator allow the open and close times to be varied between 1 s and 16 s. It is also possible to specify the open and close times independently.

The newly developed electric motor operated valve avoids the need for the air compressor, air piping installation, and maintenance that are required for the air cylinder operated valve commonly used to achieve rapid valve open and close times while also reducing power consumption by about 90% (as measured by Hitachi Metals). The use of an electric motor with excellent control characteristics also allows a range of solution options to be offered, including valve status monitoring and early detection of anomalies.

The new valve will help with the automation of piping systems and should also contribute to the reduction of customer workloads in the future.

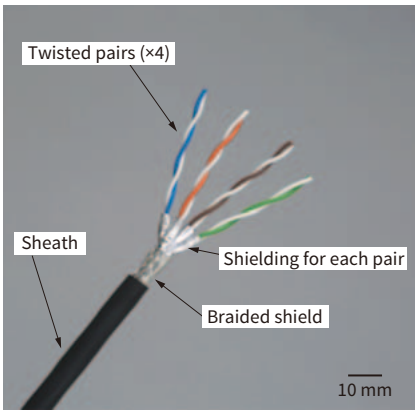
(Hitachi Metals, Ltd.)

3 LAN Cable for Overseas Rolling Stock

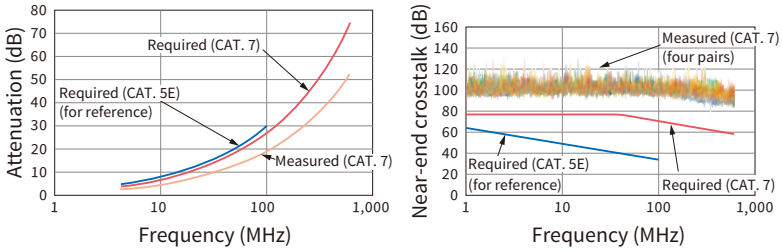
Factors such as the greater use of Ethernet in the electronic equipment on rolling stock and the provision of wireless local area network (LAN) services for passengers mean that more information than ever is being handled. This is boosting demand for rolling stock communication cabling.

Hitachi Metals has developed a category 7 (CAT. 7) high-speed LAN cable that complies with the EN45545-2* European fire safety standard for railways.

Rolling stock cables use halogen-free materials that do not emit smoke or toxic gases in the event of a fire and are required to satisfy the flammability criteria stipulated by European fire safety standards. To achieve the criteria for near-end crosstalk up to 600 MHz and other electrical characteristics requirements for CAT. 7 LAN cable, the insulation uses micro foam technology and multi-layer extrusion to reduce its



Test	Test standard	Requirement	Result
Flame propagation-single vertical cable	EN60332-1-2	Upper non-combusted region ≤ 50 mm	Pass
Flame propagation-bunched cables	EN60332-3-25	Charred length ≤ 2.5 m	1 m
Smoke emission	EN61034-2	Percentage light transmittance ≤ 70%	84%
Toxicity	EN50305	Toxicity index ≤ 6	3



3 Cable wires (left), test results for EN45545-2 European fire safety standard (top right), and attenuation and near-end crosstalk graphs (bottom right)

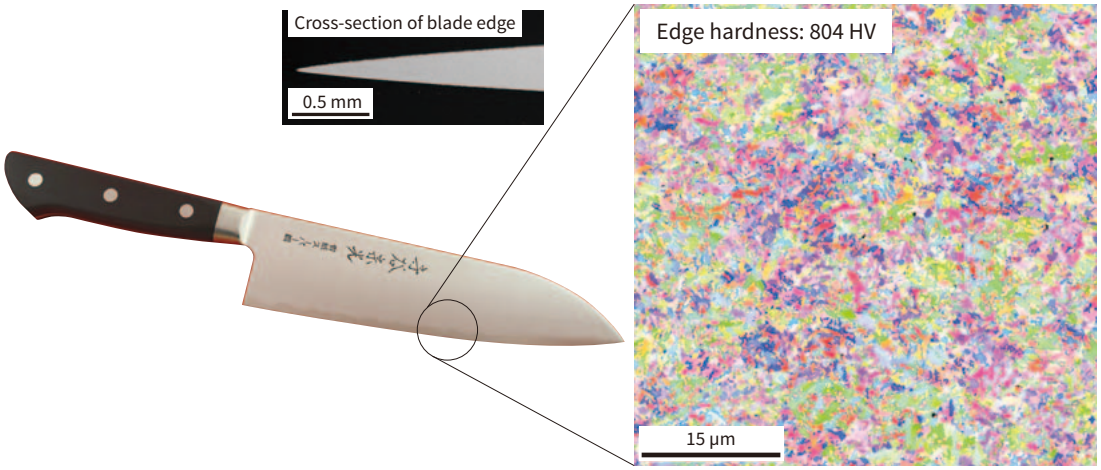
dielectric constant and flammability, while each twisted pair of cores is covered with aluminum foil tape. All of the fire safety requirements are satisfied, with the sheathing being made from a mix of materials that meet the low-smoke and low toxicity requirements.
(Hitachi Metals, Ltd.)

* EN: European Norm

4 More than Century-long Tradition of Cutlery Steel Production

Knives are one of the conveniences of civilization and essential for daily life. In 2020, Hitachi Metals will mark the 121st consecutive year of production of the specialty steel used to make kitchen and other cooking knives in the San'in region of Japan that has supported traditional Japanese *tatara* iron-making since the Yasugi Works first commenced operation. The steel is used both in *wabocho* Japanese kitchen knives and in western-style knives.

Among the many different characteristics required for knives are hardness and the fineness of the microstructure, which are needed for the particularly important requirement of ensuring sharpness. Electron backscatter diffraction (EBSD) using an electron scanning microscope provides a way to analyze the fine microstructure (crystal grains) at the knife edge. The technique was used to view the microstructure of kitchen knives made from Aogami Super cutlery steel,



4 Knife made from Aogami Super cutlery steel and EBSD image of blade edge (knife made by Moriya Munemitsu Co., Ltd.)

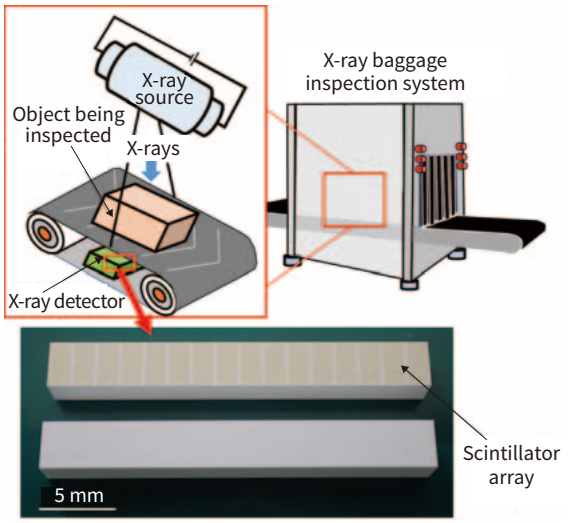
a steel commonly used for this purpose. The steel contains a large number of hard carbide particles with microstructural features in the sub-2 μm range that give it a hardness of 804 HV.

By applying micro-control techniques for achieving fine control over microstructure to the Yasugi Specialty Steel brand of high-quality specialty steel, which includes cutlery steel, the company intends to support knife-making by supplying cutlery steel that enables users to enjoy the sharpness of kitchen and other knives. (Hitachi Metals, Ltd.)

5 Scintillator Array for Security Applications that Combines High Performance with Low Cost

Demand for the use of X-ray baggage inspection to perform security checks has grown since the 9/11 terrorist attacks against the USA in 2001. Because of the difficulty of checking bags lying on top of one another for inspection using conventional two-dimensional X-ray imaging, recent years have seen wider adoption of three-dimensional X-ray computed tomography (CT) imaging for this application. Furthermore, the detection scintillators* used in these X-ray CT inspection systems required the same high output and rapid response (low afterglow) as medical X-ray CT systems.

Hitachi Metals has experience with the commercial production of scintillator arrays for medical X-ray CT systems, and the characteristics of the gadolinium oxysulfide (Gd_2O_2S) (also abbreviated as GOS) used in these systems are such that the material also satisfies the requirements of security inspection systems. The demand to keep costs low is particularly strong in security applications, however, so that it is necessary to reduce the cost of the scintillator arrays. To meet this customer need, the company has developed a scintillator array for security use that features high performance and low cost by making improvements to the GOS used in previous systems and establishing an array fabrication process that uses fewer raw materials. (Hitachi Metals, Ltd.)



5 Diagram of X-ray baggage inspection system

*A material that emits light in response to exposure to radiation (in the form of X-rays or γ rays).