Electronics Material Technology of the Nippon Steel Group
Advanced Materials of Nippon Steel Chemical: Opening up A New Age of Multimedia

Series 3: Hydrogen Production Technology Using Sensible Heat from Iron- and Steelmaking Processes
Technological development is proceeding of a technology to produce hydrogen, a promising clean energy, using hitherto unrecovered COG sensible heat.
With the effective utilization of iron and steel by-products as the basic thrust, Nippon Steel Chemical Co., Ltd. has aggressively pursued a fusion of by-products and coal chemistry. This move and the accumulated expertise of the company have combined to enable Nippon Steel Chemical to steadily expand its scope of operations to cover high-performance materials and advanced electronics, including information-recording materials. Within the most advanced field of electronics materials, Nippon Steel Chemical — a member of the Nippon Steel Group, a leading industrial entity in Japan — is challenging itself to develop novel materials conducive to building a new age of multimedia.

A Unique Product Group Emerges from Coal Chemistry
The pursuit of new business opportunities at Nippon Steel Chemical began in 1982. In tandem with extensive research and development activities that encompassed both coal chemical and petrochemical seeds, various pioneering attempts have since been made to meet diverse emerging needs, with many rewarding results obtained especially in the field of coal chemistry — the core of Nippon Steel Chemical's business. To illustrate, by distilling coal tar generated as a by-product from coke-oven operations, various aromatic compounds were obtained. Use of
these aromatic compounds made available extraordinary polynuclear aromatic resin materials, leading to the development of unique advanced materials. Aromatic resins are superior in heat resistance to aliphatic resins obtainable from oil. Besides, their excellent photo- and thermo-curable properties ensure ease of working. Thus, these resins can well be said to be optimum for use in electronic devices that must withstand extremely high soldering heat during their assembly or need to be subjected to elaborate processing on the order of micrometers.

This issue introduces three typical electronics materials already marketed: ESPANEX, FINE RESIN and ESAREX. Nippon Steel Chemical has positioned the business areas associated with these three advanced materials as the core of the company’s next-generation business operations. Thus, the input of the company’s managerial resources, including research and development expenses and equipment investment, has now focused on them.

ESPANEX Meets the Needs of Portable IT Apparatus

ESPANEX is an adhesive-free, polyimide- and copper-clad laminated sheet for flexible printed circuit boards of Nippon Steel Chemical’s own development. It is moving into the limelight now as circuit material. This is because it meets the need for downsizing, lighter weight and higher performance of mobile phones, personal date assistants, personal computers, digital cameras, digital video cameras and other various portable IT apparatus.

Conventionally, adhesives were used for bonding insulating materials, polyimide and copper. However, when exposed to the high heat of soldering for packaging circuit boards or similar conditions, dimensional standard of circuit boards got out of order by expansion and contraction of adhesives, or the adhesion between copper and polyimide was weakened, thereby impairing the performance and reliability of electronic equipment. The adoption of ESPANEX overcomes this weakness since it involves no adhesive.
ESPANEX now possesses a high reputation worldwide as an excellent material for high-density interconnection and folding assembly, including those for peripheral circuits. To take mobile phones as an example, ESPANEX retains a 10% share of the world market for printed circuit boards, but as much as 80% of the market for mobile phones of the liquid crystal color-display type and access function to Internet requiring far higher performance to deal with the extremely high volume of information.

Nippon Steel Chemical now envisions the electronic materials business field as a next-generation profit basis and is fast approaching the task of developing new advanced materials to open up a new age of multimedia.

**FINE RESIN Enables Images of Greater Brilliance to Be Produced**

Nippon Steel Chemical’s advanced materials are increasingly applied in many parts of flat-panel displays (FPDs), centering on resist materials for liquid crystal color filters. FINE RESIN satisfies the need for greater FPD brilliance. It has been developed by making use of research on cardo resin. FINE RESIN is particularly superior to acrylic resins in terms of heat resistance, clarity and patterning property (patterning refers to where an ink coating is first applied and then part of the coating, where necessary, is irradiated by ultraviolet rays to remove the section in an alkaline atmosphere).

Since the inception of FINE RESIN business in 1994, its FPD-related sales have shown a five-fold gain. With an eye toward further progress in the FPD-related business, Nippon Steel Chemical will continue to take up the challenge of new research and development in this field.
ESAREX Ensures Optimum Packaging

Semiconductor materials will take on greater importance as a pillar of Nippon Steel Chemical’s advanced materials businesses in the future. Nippon Steel Chemical provides a constant stream of new materials for new-generation LSI packages, in addition to epoxy resin-based pastes and films and photosensitive cardo resin for conventional semiconductor packages. Typical among them are various types of bonding and adhesive agents marketed as ESAREX series.

The key requirement in the world of semiconductors is how to send information flawlessly. For a closely printed circuit, cardo resin having a good resolution is effective. In the case of mobile phones, paramount is how to mount semiconductor chips within an extremely small space on the circuit board. An efficient approach to this is flip chip packaging. With this method, semiconductor chips are directly bonded to a circuit board through metal bumps, in place of gold-bonding wire. Flip chip packaging minimizes the loss of signal transmission and thus is called “optimum packaging.” Nippon Steel Chemical offers a rich line-up of adhesives, as the ESAREX series, that can perform the task of bonding in a matter of seconds.

Another bonding approach is to stack multiple semiconductor chips within a single package. This substantially reduces needed space. The ESAREX series meets this requirement.

Nippon Steel Chemical will continue to come up with new materials in rapid succession for next-generation LSI packages, in addition to epoxy resin materials for conventional semiconductor packages.
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Next-generation Environmental Technology

Series 3

Hydrogen Production Technology Using Sensible Heat from Iron- and Steelmaking Processes

Energy consumption by the Japanese steel industry accounts for nearly 10% of the total national energy consumption. As a major steelmaker, Nippon Steel is pursuing the saving and effective utilization of energy to the ultimate level, and its effective utilization rate has reached 60%. The company is promoting full utilization of the remaining 40% of unrecovered energy. Among the challenging tasks is the development of technology to produce hydrogen, a clean energy, through the effective utilization of unrecovered sensible heat (waste heat) of coke-oven gas (COG).

COG as A Future Supply Source of Hydrogen

COG is generated in the process of producing coke from coal, and its main components are 50% hydrogen and 30% methane. COG generated at a high temperature of 800°C in coke ovens is once cooled, and its gaseous form is utilized as a fuel after separation and recovery of tar and pitch, the main components of which are hydrocarbon compounds. The primary task in the current R&D is how to effectively utilize COG sensible heat at 800°C and how to effectively and in greater quantities convert COG to hydrogen, a promising future energy source.

Hydrogen can generate three times the heat of gasoline per gram. Further, when combusted, hydrogen discharges only water, imposing an extremely low burden on the environment. Accordingly, hydrogen is expected to become a future clean energy source in place of petroleum. In particular, hydrogen will be used in the fuel cells of electric vehicles, and thus the demand for hydrogen will be high.
Key to Development Is the Catalytic and Low-cost Production Technologies

The reaction in which hydrocarbon compounds such as methane and tar/pitch in COG are reacted with vapor at high temperatures and are converted to hydrogen and carbon monoxide is called the “reforming reaction.” In order to enhance the reforming reaction, technological development is proceeding on the combined use of the reforming reaction and the partial oxidation reaction in which hydrocarbon compounds are converted directly to hydrogen and carbon monoxide by introducing oxygen in the reaction process. Nippon Steel is promoting two innovative technological developments with the aim of utilizing COG sensible heat at 800°C, so far unused, as the heat source for the reforming reaction and the reaction heat generated in the partial oxidation reaction.

One technology is that to effectively enhance the reforming reaction. Because substances that impede the activity of catalysts are contained in COG, when conventional catalysts are used, their activity is immediately lost. Nippon Steel participated in a two-year guiding research of the national project on the technological development of hydrogen production using sensible heat (see below), which led to the development of catalytic technology by which catalyst reactivity is difficult to be lost and regeneration of activities is easy.

The other technology is that to produce oxygen at low cost for use in the partial oxidation reaction. The technology adopts a ceramic having the unique characteristic that only oxygen permeates it at high temperatures. Nippon Steel, with other participants in the national project, is tackling the development of highly efficient partial oxidation reaction technology through the combined use of ceramics and catalysts.

Current R&D Aims at Realizing “Clean Energy Society”

The five-year “Technological Development Project for Highly Efficient Hydrogen Production Using Sensible Heat from Iron- and Steelmaking Processes” (second phase) started in 2001 as a national project of the Ministry of Economy, Industry and Trade. Nippon Steel, NKK Corporation, Teikoku Oil Co., Ltd. and the Japan Research & Development Center for Metals are participating.

By-product gas sensible heat accounts for 3% of energy structure, and COG sensible heat accounts for 1% of the 3%. But this 1% sensible heat offers the potential to supply hydrogen gas in quantity and stably.
Operating Roundup

Electrical Steel Collaboration between ThyssenKrupp Steel and Nippon Steel

Expansion of Electrical Steel Technical Cooperation between AK Steel and Nippon Steel

Obituary

Announcement of the Death of Mr. Eishiro Saito, Honorary Chairman of Nippon Steel

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in the project. The two technological developments are being promoted in the current project.

General Manager Tetsuo Sakamoto of the Surface & Interface Research Lab., the Advanced Technology Research Laboratories, is the leader of the current technological developments. He stresses, “We will clarify the technological requisites for practical application in the current five-year research project and start preparations for practical application. We forecast that fuel cells will be put into practical use around 2005 and their full-scale application will start around 2010. Carefully watching the demand for hydrogen as well as the market trends, we will promote technological developments. The current hydrogen production technology will lead to the research that aims at enhancing energy saving in the steel industry and realizing a clean energy society. We are striving for these two purposes.”

In fiscal 2005, the final year of the research project, laboratory assessment will be made on the practical application of the hydrogen production technology using the sensible heat from iron- and steelmaking processes and the verification of its application as an industrial technology and its economic advantage will also be made. Expectations are high for the achievements of the research.