

TODAY'S INNOVATION IS "TOMORROW'S BASIC"



Functional Films by DNP 2020

GUIDE TO TECHNOLOGIES, FEATURES,
AND APPLICATIONS



DNP

“Tomorrow’s

Basic”

Functional Films



Six Types of Innovation

/ Engendered by Functional Films \

DNP functional films are used in a variety of scenarios in our lives. These great many functions are divided into six different categories.

- 
Controlling Light
 This feature controls the direction of the light so that it collects in a specified spot, or is diffused, etc.
 → P.4-7
- 
Protecting What's Inside
 The product protects the contents by attributes such as gas barriers, heat seals, unadsorbability, and more.
 → P.8-9
- 
Reinforcing the Surface
 By being applied to light or heat, this technology balances excellent surface properties, like scratch resistance, weather resistance and soiling resistance, and easy processability.
 → P.10-11
- 
Decorating the Surface
 Thanks to advances in printing and transfer technologies, designs can be customized as desired.
 → P.12-13
- 
Bonding Different Kinds of Materials
 Drawing on the melting and curing characteristics triggered with heat and / or electricity, dissimilar materials can be bonded together.
 → P.14
- 
Conducting Electricity
 By arraying minute electrodes on the inside, it can be applied to electronic parts including transparent film for touch panels.
 → P.15

DNP functional films have many features including light control as well as protection. These films are now considered essential materials, continuously working to facilitate today's safe-and-comfortable lifestyle. At times they have been used to replace existing materials to improve benefits, while at other times they play a more revolutionary role in creating the products of the future. The film is being used in more and more applications each year.

The transparent barrier film achieves safety and peace of mind in packaging

By making the barrier film—designed to keep the inside contents from deteriorating—transparent, the result is even better convenience for items like retort pouch foods and medical pouches.

→ [Case Studies in Innovation (P.09)]

This carrier box is designed to withstand changes in temperature, lowering transport costs

This vacuum insulation box, which incorporates barrier film, is an effective means of lowering distribution costs via consolidated transport—even through zones of varying temperatures.

Boosting weatherability of surveillance cameras and stoplights using heat-generating film

This film generates heat using minimal electricity, preventing condensation and snow accumulation on glass used in surveillance cameras, stoplights, etc.

Decorative film adorns car interiors

This film can give a variety of appearance, like wood look, metal look and textured surface, to your vehicle interior.

→ [Case Studies in Innovation (P.13)]

Smart phones get smaller and lighter

By switching the outer materials of the lithium-ion battery—essential to mobile devices—to film packaging, devices are rendered both lighter and slimmer.

Plastic Glazing enables automotive to reduce weight

This technology contributes to light weight and design flexibility.

→ [Case Studies in Innovation (P.11)]

Maximizing producer profits by boosting photosynthesis of farm products

This sheet-type surface-emitting LED lighting—light, thin, and easy to set up, helps to stabilize production volumes at plant-growing facilities.

→ [Case Studies in Innovation (P.07)]

Transparent conductive film enables high-performance features for touch panels

DNP's low-electrical resistance, highly transparent conductive film contributes to touch panel device development.

Effective use of natural light: key to cutting energy use

By attaching this film—which controls the direction of natural light—to glass, rooms are made brighter, while at the same time energy used for lighting is reduced.

Achieving smooth writing by digital pen/as well as the prevention of screen reflection

By re-creating the attributes of pencil and paper, and reducing screen reflection, this film boosts tablet functionality.

→ [Case Studies in Innovation (P.05)]

DNP Expands Business by P&I (Printing & Information) Technology Applications and Development

DNP has created printing plates to accurately re-create characters and images in high resolution, outputting large numbers of copies on paper and other materials. Many of DNP's sophisticated printing technologies, which the company has cultivated since its founding, represent our core technologies, having proved essential to the development and manufacture of numerous functional film products.

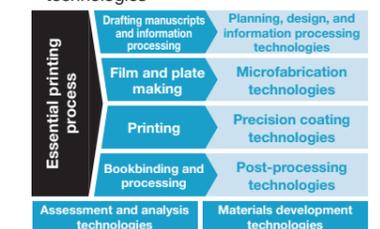
For example, the process used in plate-marking to create fine patterns led to DNP's microfabrication technology, which has facilitated manufacturing on the scale of 1nm (1 millionth of one mm). Meanwhile, the process that enabled thin, uniform

spreading of ink led to the precision coating technology capable of adding features to a range of materials. By combining these with other technologies such as thin film control and multi-layering, DNP has arrived at other sophisticated and diverse technologies, which in turn have led to the development of a myriad of functional film products for both companies and individual consumers.

We have fostered innovation through the power of P&I, engendering products and services imbued with entirely new value. Look forward to the "Tomorrow's Basic" or new value that such DNP contributes to create.

A DNP Innovation Story

■ The essential printing process and our technologies



See the following site for further details on products and services shown in the Guide.
 (→ https://www.dnp.co.jp/eng/biz/solution/products/functional_film.html)

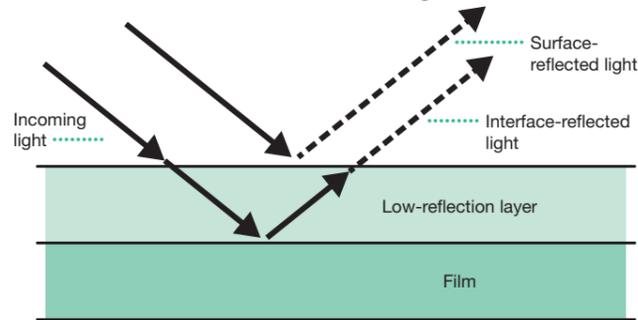
Controlling Light

The film is engraved with a fine pattern and coated with optical-property materials, optimizing based on optical design incorporating materials with inherent optical properties. The result is improvements on aspects including light transmission, reflection, glare, and diffusion. At DNP, we are working to reduce indoor lighting energy consumption and boost photosynthesis in farm products, as well as incorporating these films in products to prevent reflection in displays and automobile windshield glass. We are also conducting ongoing research in these areas.

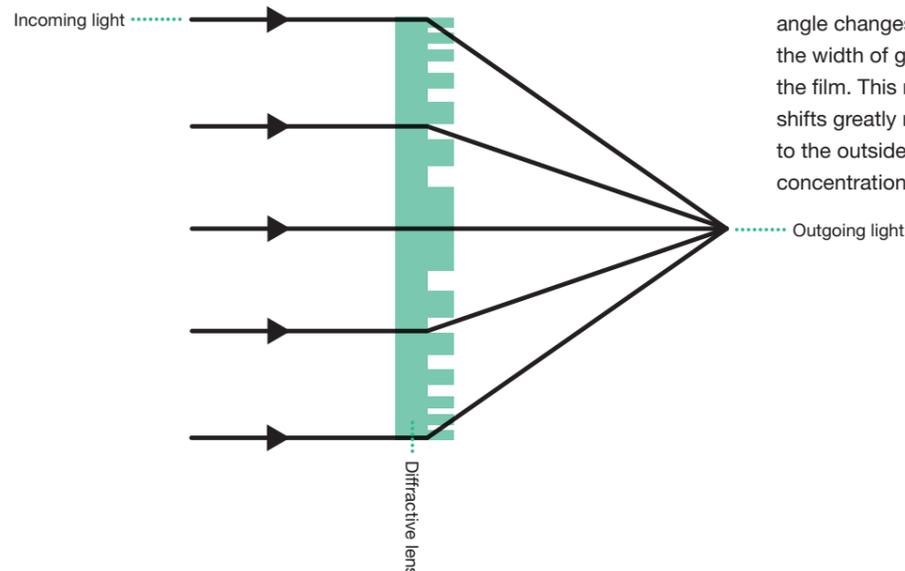
Precise Control of Light Directionality and Color Optical Design Technology

This technology controls light transmission, reflection, glare, and diffusion through a combination of materials imbued with specialized optical characteristics, and surface shape. DNP holds a number of related technologies stemming from optical design, including the manufacture of holograms capable of recording three-dimensional images. For instance, with the low reflection film to the right, light interference negates reflecting light, reducing the reflection of surrounding objects into the screen.

Reflection is reduced by effectively utilizing the interference of surface-reflected light and interface-reflected light



Angle of outgoing light changed



In diffractive lenses such as that shown to the left, the diffraction angle changes in accordance with the width of grooves engraved into the film. This means that the angle shifts greatly moving from the center to the outside edge, allowing for concentration of light.

[Controlling Light] – Applications in the Field of Education – Pioneering New Uses by Adding New Features to Anti-Reflection Film

Column

Case Studies in Innovation

DNP film improves the writability by digital pens, answering to classroom needs

The School Education Law will be revised in 2020 in tandem with curriculum guidance revision. Because current circumstances demand use of tablets and digital textbooks in classes, it is assumed that children will use more and more digital pen. However, the glass surface of tablets makes the screen difficult to see due to the reflections from indoor fluorescent lights as well as outdoor lighting, plus causing digital pens to slip and making it difficult to write.

DNP furnishes new film to improve convenience, adding new features to its anti-reflection film—on the market from some time ago—which helps prevent glare and reflections. One such product is our film for digital pen writing comfort. With a view to improving ease and comfort of writing, DNP focused on the friction coefficient and amplitude between the glass and the digital pen. Through the use of our own coating technologies, we brought our numerical values closer to the pencil-and-paper experience, specifically the ideas of *tome* (pause stroke), *hane* (hook stroke), and *harai* (sweep stroke). Additionally, highly effective anti-reflection properties preventing indoor fluorescent lighting reflection—as well as anti-smudge surfacing designed to better mask fingerprints—are proving extremely useful in educational settings.

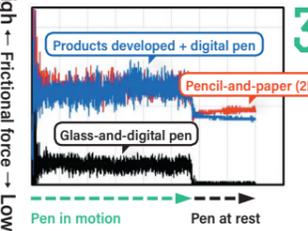
1.



2.



High → Frictional force → Low



3.

1. DNP achieves a pen-and-paper feel by boosting the friction coefficient of the glass surface with our unique coating technologies.
2. Anti-reflection and anti-smudge features are added.
3. By approaching the frictional coefficient of pencil-and-paper at the points where the pen is in motion and again where it is at rest, a unique smooth writing touch has been possible unlike the conventional glass-plus-digital pen use.

[Related Products (1 of 2)]

DNP film for digital pen writing comfort

This film enables simulation of the pencil-and-paper experience, even with a digital pen, specifically the ideas of *tome* (pause stroke), *hane* (hook stroke), and *harai* (sweep stroke). At the same time, its anti-reflection properties negate reflection caused by fluorescent lights.

DNP lighting film

This film effectively utilizes natural light to keep rooms bright by reflecting and diffusing light coming in from the window to the ceiling or far parts of the room.

Viewing angle control film for automobiles

This film, designed for automotive displays, increases brightness from the driver's perspective, while at the same time preventing reflection on the front glass.

Electronic shade

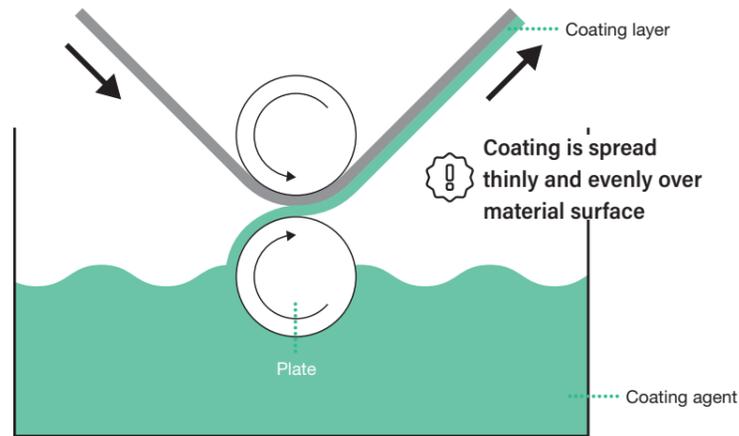
This product rapidly switches electronically between transparent and shade settings. It automatically (electronically) controls light transmittance and tone as desired.

Optical film (AGLR/Clear LR)

This film is ideal for a wide variety of applications including TV screens, PCs, smart phones, automotive consoles, and more, through a high degree of visibility, superior surface hardness, and anti-grime attributes.

Wide viewing angle film

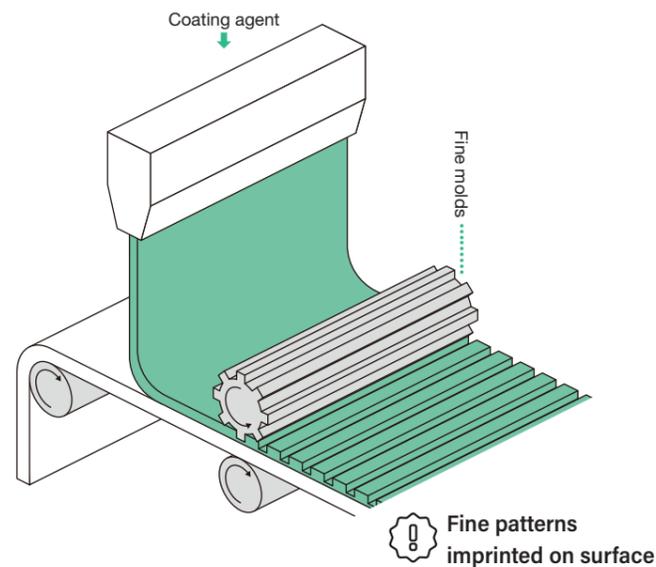
This protective film controls changes in tone and prevents light from dimming caused by looking from an angle in liquid crystal displays, boosting tonal expression.



A Thin, Even Layer of Coating Material Is Spread over the Surface

Coating Technologies

This technology renders polymer materials into a state of ink, evenly spreading them over materials such as paper and film, and bonding them to the surface. DNP has generated a wide variety of technologies, including liquid crystal coating designed to block outside light reflections for OLED displays, as well as high-speed film coating technology used in the manufacture of inkjet ribbons used in dye-sublimation thermal transfer printers.



Transferring Fine Patterns

Molding Technologies

This technology uses convex/concave-surface metal, glass, and resin molds to transfer these convex/concave shapes onto a base material surface. It stems from the printing processes where plates are synchronized with printed patterns. It is ongoing to develop further—in nanoimprinting technology—in which patterns of 20nm or smaller are transferred. Not only optical features but also textures are effectively transferred.

[Controlling Light] – Applications in the Field of Agriculture –

Increasing Producer Profits by Boosting Photosynthesis

DNP flexible LED panel to optimize plant-growing facility lighting environments

In recent years, consumers have become more and more aware of health issues, which has led them to demand safe-and-fresh farm products. Traditional open-field agriculture has always been greatly impacted by problems such as weather patterns, blights, pests, and more, such that the concept of stable supply through plant-growing facilities has now captured the interest of the public. Also, as people are more aware of the need for a safe food supply, demand for pesticide-free or low-pesticide cultivation is on the rise.

To satisfy these needs, DNP has applied film-processing and microfabrication technologies—developed from printing technologies—to commercialize thin-and-light panel-type surface-emitting LED lighting “DNP flexible LED panel” for plant-growing facilities.

These panel-type LED lighting products are utilized as a light source for artificial-light plant-growing facilities. Light and flexible, they can be situated in many different places including the ceiling and sides of a growing space.

Because they are surface-emitting, light is emitted evenly, helping to avoid situations where the plants only grow under the light, and also preventing burning.

Where greens such as lettuce and spinach are grown under these lights, productivity has climbed—yield increased and cultivation time period shortened—compared to facilities using conventional tubular fluorescent or LED lighting (compared to tubular LED lightning, 1.5-2.0 times greater yield, study by DNP). With setting up DNP’s light dispersion film REFLEMOR on the outer edges of the cultivation area, the lighting environment is further improved, boosting yield even more.



1. DNP flexible LED panel specifications:
Panel thickness: approximately 0.1 mm
Panel unit: 1 (560 mm×390 mm)
Weight: Less than 100 g
Flexible and lightweight
2. Light quantity
PPFD (photosynthetic photon flux density): 250μmol/m²/s, at 20 cm under lighting (actual measured value)
Surface-emitting light is evenly diffused

Column

Case Studies in Innovation

Transparent Screen Technologies, Garnering Attention from the Public both Overseas and in Japan

An exhibit showcasing transparent screens was staged at one of the largest cutting-edge technology exhibitions in the field of IT, held in the U.S. in March 2019. Several transparent screens were lined up in the booth, showing bright, clear

images that appear to float, drawing many visitors and inspiring interest in the products. As the event was featured in local news and other media coverage, the transparent screens have also stolen the spotlight overseas.



[Related Products (2 of 2)]

DNP light dispersion film REFLEMOR®

With a high level of light reflectivity and anti-smudge properties, this product boosts photosynthesis by reflecting light on the backs of leaves. It can also be used as reflective material in artificial light plant-growing facilities.

DNP flexible LED panel

This light-and-thin, flexible surface-emitting light panels are used in cultivation units at artificial-light plant-growing plants.

Transparent screens

This screen projects clear images that appear to float in space, thanks to its superior front-surface brightness and transparency, even in well-lit areas.

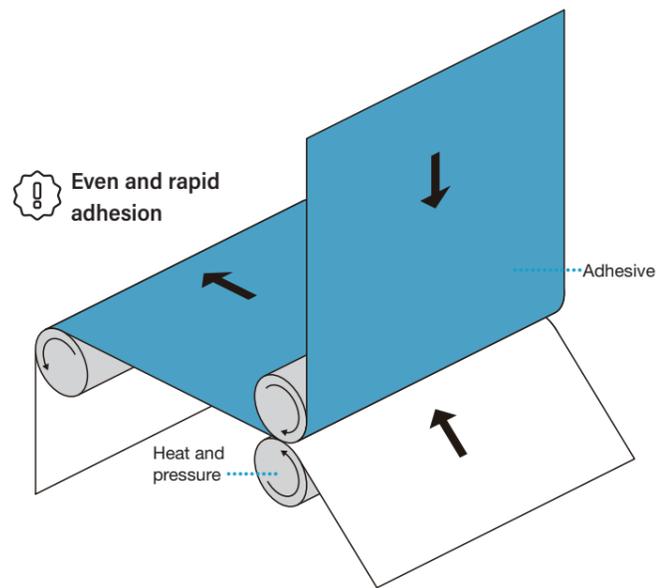
DNP hologram

This technology has various applications, ranging from anti-counterfeiting measures for passports, ID verification, cash vouchers, industrial products, and more, to packaging and premium product design.



Protecting What's Inside

The product protects the contents by bonding film materials with attributes such as gas barriers, thermoformability, unadsorbability, and more. At DNP, we are working to step up use in retort pouch food items, insulation boxes for refrigerated foods, batteries, outer packaging for precision equipment, chemical liquid protection, as well as conducting research in these areas.

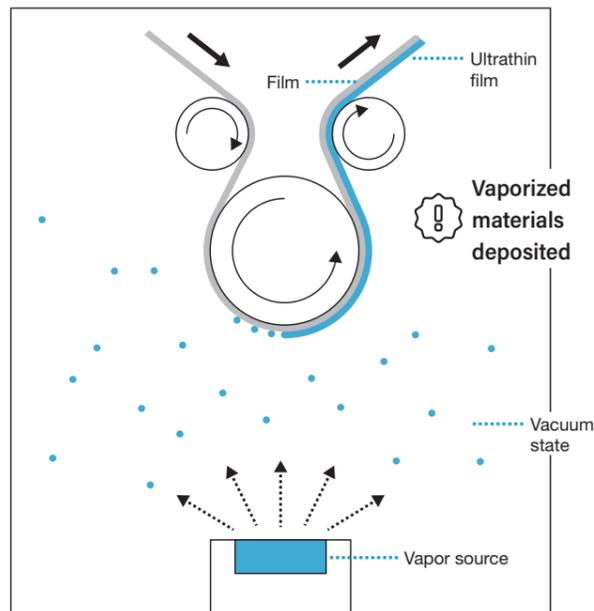


Adding Features by Bonding Materials of Different Compositions Laminating Technology

This technology bonds separately-produced materials including films, metals, resins, etc. Attaching multiple functional materials depending on the intended use produces even better results. At DNP, we have a long history of manufacturing film packaging for food products, and as such we hold processing technologies compatible with a wide range of functions and shapes.

Creating an Ultrathin Film by Taking Advantage of the Vacuum State Vacuum Deposition Technology

In a vacuum by evaporating materials and depositing them onto a base of plastic film or other material, this technology enables the coating of highly pure ultra-thin films. DNP holds technology to generate ultrathin film of molecular level, which is a basic requirement in the semiconductor manufacturing field.



(Protecting What's Inside) – Electronics/Medical/Industrial Fields –

Column

More and More Applications Answering to Needs: the Ever-Expanding Possibilities of Barrier Film

Transparent vapor deposition film (IB-Film®) featuring superior gas barrier, moisture resistance, and transparency properties

Needs for the protective features of barrier films, as exemplified by retort pouch foods, are on the rise not only for conventional food products but from a range of different fields. To satisfy to these needs, DNP is working on both improvement of existing technologies such as gas barrier and moisture-proofing as well as flexibility on shapes, and on new technologies.

DNP's transparent vapor deposition film (IB (Innovation Barrier) - Film), developed out of our own deposition and laminating technologies, is being adopted in various sectors due to its adaptability to market needs. The technology holds potential for various applications including flexible display components and battery packaging in the electronics field; blood transfusion bags with indicators showing any quality decline: containers for transport and storage of liquid medicines.

Protective properties add flexibility, enabling barrier films to replace the functions of existing materials such as aluminum and glass. More possibilities lie ahead for these technologies.



1.



2.



3.

1. Transparent vapor deposition film (IB-Film®) 2. Food product applications 3. Examples of advanced attributes meeting market needs (electronics field, etc.)

Case Studies in Innovation

[Related Products]

DNP transparent vapor deposition film (IB-Film®)

This transparent high barrier film utilizes vapor deposition technology and special coatings to make it exceptionally resistant to water vapor and oxygen.

DNP multifunction insulation box

This product enables transport over many hours of frozen or chilled products in regular vehicles, all without a power source. The resultant consolidation of cargo allows for a reduced number of trucks dispatched.

DNP heat-resistant adhesive film

This product is extremely useful for electronic products requiring high-temperature resistance, as well as the semiconductor manufacturing process, protection of base plates, chemical resistance to etching, preventing adhesive from migrating during high-temperature processing, and more.

DNP chemical carrier bag

This inner bag is inserted in liquid containers for chemical liquid protection. Since the bag is replaced after use, and can also be re-used, it reduces costs associated with washing as well as new container purchases. It also helps prevent contamination and stabilizes the quality of the contents.

DNP battery pouch

By switching the outer materials on lithium-ion batteries from a metal can to light thin-film coating, batteries are rendered both slimmer and lighter.

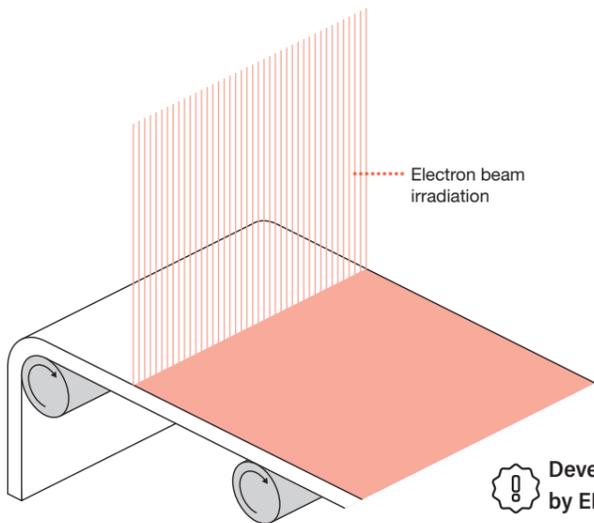


Reinforcing the Surface

By being applied to light or heat, these films, coated with special ink, can give excellent surface properties, like scratch resistance, weather resistance and soiling resistance.

They are also has good processability like bending and molding process.

DNP is working on development and research of these films for housing and mobility application.



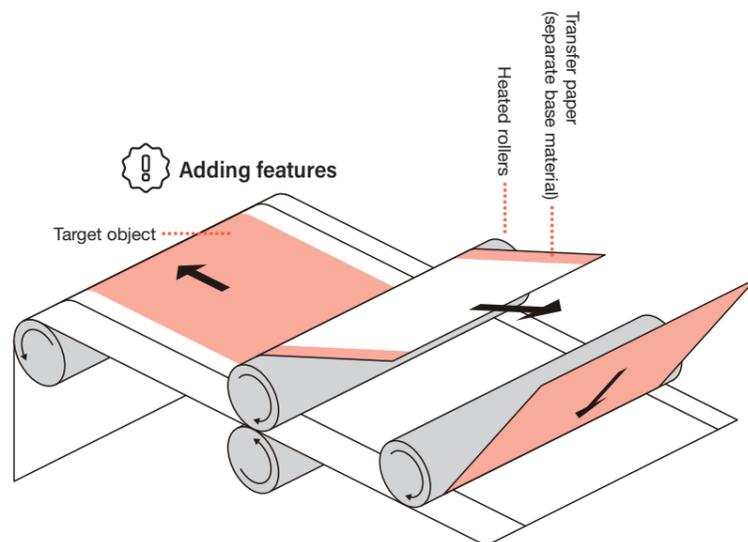
Instantly Boosting Performance of the Object by Electron Beam Radiation EB® Hardening Technologies

This technology instantly improves performance of resins and films by electron beam radiation. Depending on the type of resin used, as well as conditions of irradiance, the process can add properties of scratch-resistance, weatherability, and soiling resistance to an object.

Developing required features by EB radiation.

Required Features Are Added via Different Base Materials Transfer Technology

With this technology, instead of directly coating an object with ink or other materials, other base materials are coated and pressed on plastic, glass, or metal, imprinting only the characters or patterns via hot press.



(Reinforcing the Surface) – Applications in the Field of Mobility –

Resolving Mobility-Related Weight Issues with Film-Transfer Plastic Glazing

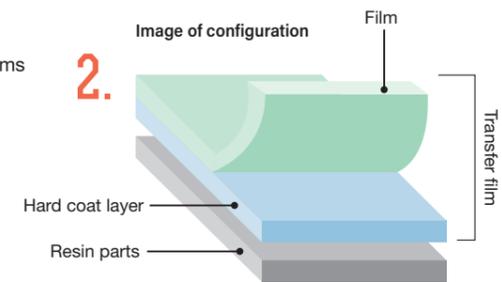
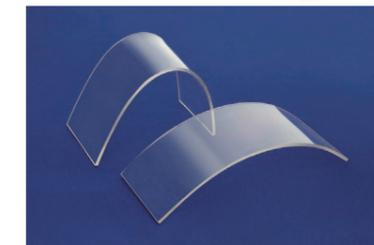
“DNP ultra weather resistance hard coat transfer film”

Achieving scratch-resistance, weatherability, and formability

As electric vehicles are becoming more and more mainstream, one issue that has become a focus of competition in the development stage is the process of making vehicles lighter by plastic glazing. The material known as plastic glazing is roughly half the weight of ordinary glass, but also has numerous other advantages: it exhibits excellent formability, impact resistance, and heat resistance. It does have an Achilles heel, however, in that it falls short compared to glass on weatherability and scratch-resistance.

To address these circumstances, DNP has developed plastic glazing whose surface is treated with “DNP ultra weather resistance hard coat transfer film” — boasting properties including superior hardness, weatherability, wear resistance, and chemical resistance. The product is also well regarded for reducing the load of manufacturing process by transferring the film during injection/extrusion process.

This product is used in the field of mobility, including in gasoline powered cars, for window shield, rear window, sun roof, etc. DNP seeks to apply this product to emblems with millimeter wavelength radar which is required for autonomous driving or safety equipment.



1. This is an example of plastic glazing of “DNP ultra weather resistance hard coat transfer film”
2. Image of configuration

Column

Case Studies in Innovation

[Related Products]

Super durable hard coat transfer film & resin parts

Transfer film with excellent hard coat and formability. This product is used for plastic glazing.

Electron Beam (EB) cured exterior film

This highly weatherable decorative film answers to needs in recent years for wood-panel looks in exterior designs for public spaces and commercial facilities.

Flexible hard coat film

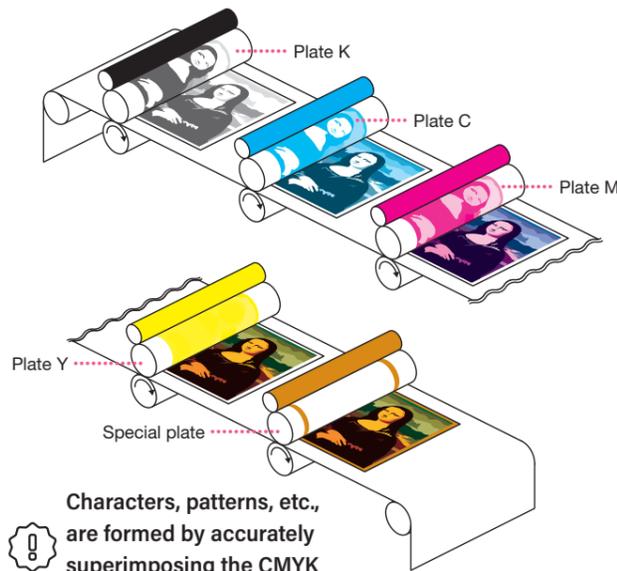
This hard coat film is suitable for foldable display surfaces, exhibiting superior qualities of hardness, curvatures, and scratch-resistance.



Decorating the Surface

Surface treatment with film can give not only functions but also colors and designs to a product and it also can achieve three dimensional design with textured surface.

DNP seeks to apply the products to variety of packaging design, housing and car interior.



Characters, patterns, etc., are formed by accurately superimposing the CMYK and special plates.

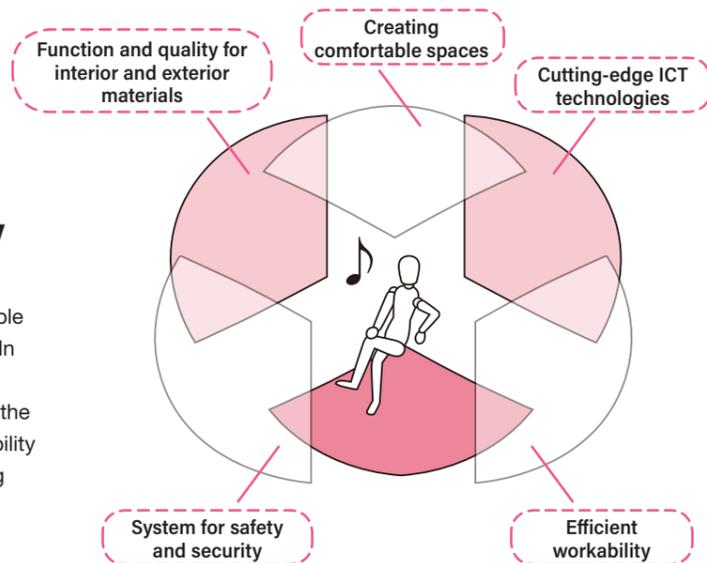
Rich Color and High-Resolution Patterns Printing Technology

From design manuscript, DNP can reproduce high-resolution images by creating cylinders based on C(Cyan) M(Magenta) Y (Yellow) K (Black) separation.

Also DNP can offer special effects such as gloss appearance and three dimensional appearance. For interior decoration purpose, DNP uses special separation cylinders with special CMYK mixed inks.

Designing Comfortable Spaces without Limitations on Materials Space Design Technology

This technology enables arrangement of comfortable spaces combining floor, wall, and ceiling designs. In addition to our know-how acquired through communication with consumers for many years in the business, DNP achieves unique designs with flexibility unrestricted by the materials by utilizing its printing technology.



[Decorating the Surface] – Applications in the Field of Mobility –

Developing Next Generation Decorative Panels to Achieve Advanced Seamless Design

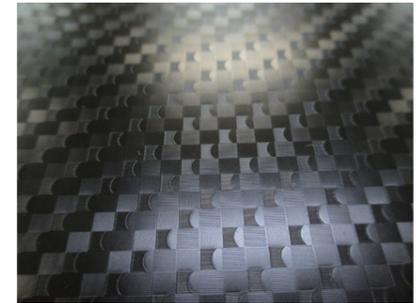
Next generation decorative panels offer more comfortable interior

Past few years, vehicle multifunctionality requires more functional equipment like displays, switches and meters. If these various types of equipment are laid out randomly, the design will be spoiled.

With advancing autonomous technology, automotive interior becomes more like a living space, which requires more integrated design from a comfort perspective.

For this reason, DNP has developed next generation decorative panel which can show "brilliant images on demand", by utilizing DNP's unique optical technology and decoration film technology and know-how acquired through many years in automotive interior and housing business.

DNP offers new concept for comfortable and refined seamless automotive interior by integrating decoration and display function.



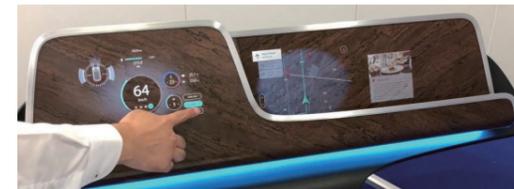
1.



2.



3.



1. Film with an fine convex/concave patterns on the surface. 2. Backlit decoration sample. When illuminated from the backside, the pattern and color changes as shown in lower right. 3. Wood look panel turns into display, navigation or touch panel switches on demand.

Column

Case Studies in Innovation

[Related Products]

Next generation decorative panel

The panel offers seamless interior design by integrating refined design like wood or geometric patterns and optical function like on demand display and switches.

Interior decoration

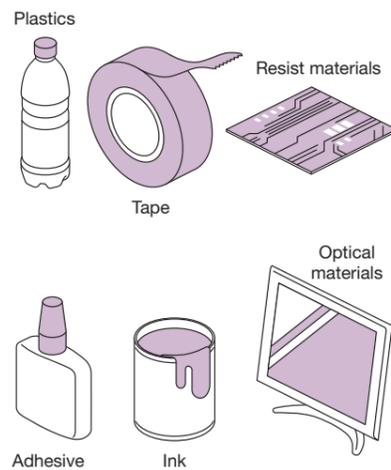
The film offers variety of designs from wood to metallic, high gloss to matte finish, smooth to textured. The film also offers excellent weatherability and scratch resistance.

Exterior decoration

The film balances decoration and function. The film works as alternative to painting process, contributes to reducing vehicle weight and can be applied for complicated shaped parts.

Bonding Different Kinds of Materials

Due to the attributes of this film such as meltability and curing through heating and chemical reaction, two different materials can be bonded together. DNP works to encourage its use in mobility products, as well as lithium ion battery components, and also conducts research in this field.



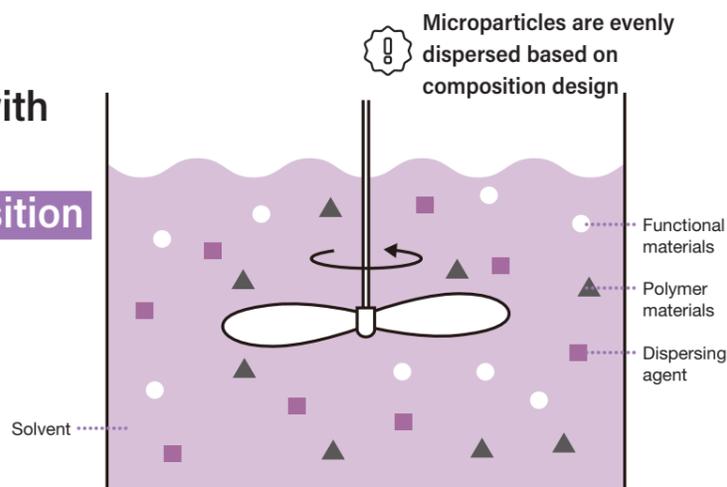
Utilized in a Broad Range of Fields such as Product Packaging and Interior Decoration Materials for Housing Polymer Materials Technology

Along with metals and ceramics, polymer materials are among the three major industrial product materials. They refer to molecularly dense materials such as plastic and rubber. They are light, shock-resistant, and easily processed after heated. Applying our own know-how, DNP develops various high-polymer materials for each different purposes including films for base material and optical functional resin.

Optimizing to Boost Performance, Starting with Materials

Dispersion and Composition Technology

This technology appropriately combines functional materials to generate ink. As one of the key technologies determining material function, compositions are designed for enhanced performance, ensuring stable quality via even dispersion.



[Related Products]

DNP welding film

This welding film enables bonding different kinds of materials including resins (primarily olefin) and metals.

DNP structural adhesive film

This adhesive film creates a tight bonding between different composition as like as metals and carbon fibers. After affixing in a simple manner—as with double-sided tape—to the adherend, it attaches with heat.

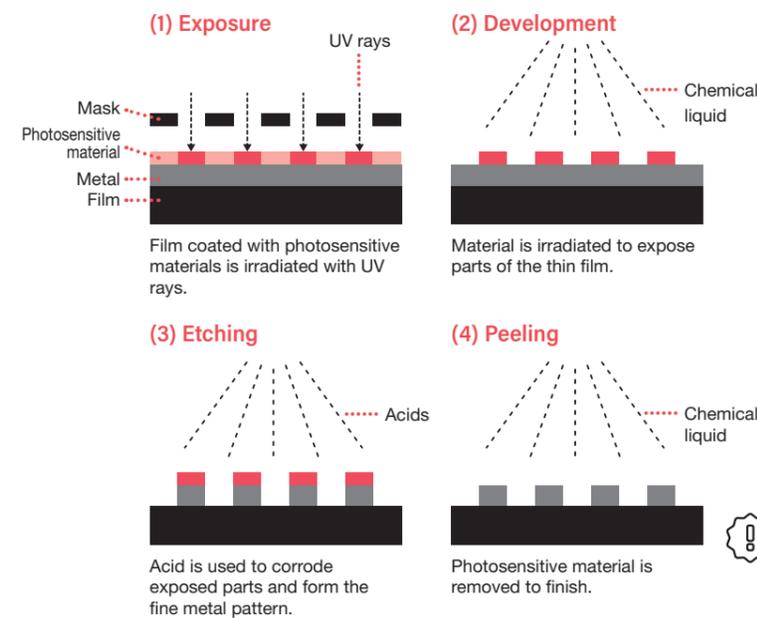
Conducting Electricity

Easily-processed, non-electricity conducting resin film is fitted with tiny electrodes on the inside, rendering it useable in electronic parts. DNP is incorporating this film applying to prevent condensation on automobiles and traffic lights, as well as to transparent films for touch panels, also implementing research in these areas.

Using Light to Form Fine Patterns

Photolithography Technology

With this technology, a base material surface is coated with photosensitive material and irradiated to create a pattern of exposed and unexposed parts. This is called photolithography. At DNP, by further developing the know-how we have gained in plate-printing processing, we are able to produce photo masks, color filters, and more at the micron level, which requires astounding precision.



[Related Products]

Film with ultrafine wiring

A 1 μm copper wire pattern is imprinted on transparent film. It will likely be utilized affixed to displays and glass surfaces in the future.

Electric heat film

This low-resistance, highly-transparent electric heat film has been achieved through DNP's patterning and fine etching technologies.

Transparent conductive film

This film, which is low-resistance in comparison to ITO, is highly transparent and flexible. It can be customized for special attributes regardless of factors such as type of base material, thickness, etc.

P&I LAB. TECHNOLOGY: a Place Where Innovation Begins

P&I (Printing & Information), undeniably a strength for DNP, operates P&I LAB. TECHNOLOGY, a space where innovation begins through collaborative technology projects with partner companies. This facility focuses on DNP's technologies, showcasing related products and services, and at the same time creates new value through

discussion. The facility has an area dedicated to the advantages of our technologies, and another exhibiting products developed using these technologies. As a special place giving rise to innovation through partnerships, DNP is pleased to share P&I LAB. TECHNOLOGY with companies from a wide range of sectors.





DNP



See the following site for further details on products and services shown in the Guide.
(https://www.dnp.co.jp/eng/biz/solution/products/functional_film.html)

Dai Nippon Printing Co., Ltd.

3-5-20, Nishi-Gotanda, Shinagawa-ku, Tokyo, 141-8001, Japan

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