ThreeBond
TECHNICAL NEWS

ThreeBond Technical News
Issued July 1, 2014

84

Light-curing Adhesive for Image Sensors and Optical Pickups

Introduction

Light-curing adhesives are used in a wide range of fields thanks to fast curing which shortens manufacturing process time. At ThreeBond we have developed, manufactured and released a variety of light-curing adhesives for hard disk drives (HDD), liquid crystal panels and other electrical/electronic devices that meet customer application needs.

Recent years have seen electrical/electronic devices grow smaller and lighter. With this progression, optical devices such as image sensors used for digital cameras and cameras on smartphones as well as optical pickups used for computers and other light-using devices have also grown smaller. As the designs for such devices diversify, the adhesives used must exhibit high bonding strength in a small area for various materials while also suppressing misalignment of the optical axis both before and after curing, and overcoming hurdles such as resisting heat caused by high densities of electronic parts.

As a solution to the above problems we are proud to present ThreeBond 3036G, ThreeBond 3038 and ThreeBond 3038B, light-curing adhesives for image sensors and optical pickups that can handle both conventional mercury lamps as well as UV-LED light sources.

Hereafter, ThreeBond is abbreviated as TB.

Table of Contents

1. Required Properties

The common feature of image sensors and optical pickups is their use of light. These devices perform their functions by accurately capturing light through lenses, mirrors, prisms and other optical components.

For this reason, rather than simply requiring adhesion to specific adherends, light-curing adhesives for affixing parts of image sensors and optical pickups require the following properties.

(1) Bonding to various adherends

Depending on the parts used, adherends range from glass to metals, plastics, and this range of different materials continues to increase. The adhesive must be able to bond with this variety of materials.

(2) Suppressing optical axis misalignment

Image sensors and optical pickups are affixed using an adhesive after the optical axis (optical path) is adjusted to be within a very narrow target range of only a few μm. Adhesive contracts as it cures, and a large contraction ratio can cause misalignment in the optical axis (Fig.1). Therefore, adhesive with a low shrinkage ratio is required. The three adhesives introduced in this article boast a low contraction ratio of around 3%.

(3) Low amount of change due to environment

Misalignment of the optical axis occurs during curing, and can also occur due to environmental conditions such as high temperature and humidity or due to sudden changes in temperature. In order to ensure intended function, it is vital that parts alignment in image sensors and optical pickups not be disrupted while ensuring that adhesive strength is not reduced.

We developed and released our light-curing adhesives with the characteristics required to solve the above issues while also being able to handle UV-LED light sources. In the following sections, we will introduce TB3036G, TB3038 and TB3038B alongside the materials they are used with.

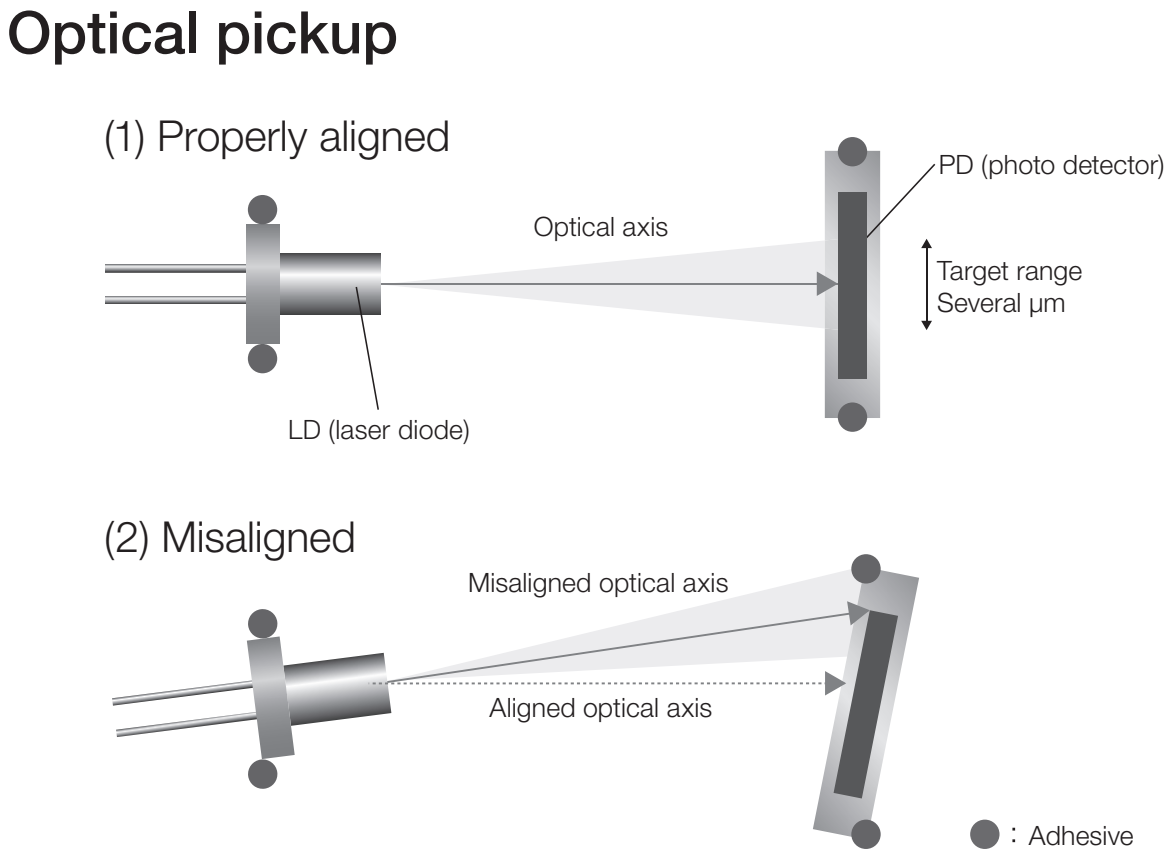


Fig. 1 Misalignment

2. Parts Used

■ Image sensors

Currently, the CMOS sensor is the main image pickup device equipped in digital and smartphone cameras (Fig. 2). The camera is vital to image quality performance because it is responsible for recording the image by exposing the image sensor to light entering through the lens. This is the heart of the camera, and TB3036G, with its low curing contraction ratio, and TB3038B, which possesses high bonding strength to metal, are used for affixing these part.

Image sensors tend to be larger the higher the image quality required, but this also means an increase in weight and stronger adhesion is then required to handle this. Additionally, any misalignment in the image sensor will negatively impact images shot, so this must be suppressed.

■ Optical pickups

Optical pickups are devices used in the laser light sources, receivers, lenses, mirrors and other optical parts for audio and video playback and recording with optical drives for CDs, DVDs, BDs, etc. These lasers are output by an LD (laser diode), then reflected and transmitted by a mirror or lens and captured by a PD (photo detector) to perform recording or playback. The LD that outputs the laser and the PD that captures it must have high resistance to the heat that so easily builds up and must suppress misalignment in order to accurately record and play back data.

Light-weight and highly heat-resistant materials are required for these parts, so PPS, aluminum, epoxy glass and other materials that are difficult to bond to are used. This is why TB3038, which exhibits high adhesive strength for a variety of materials, is used.

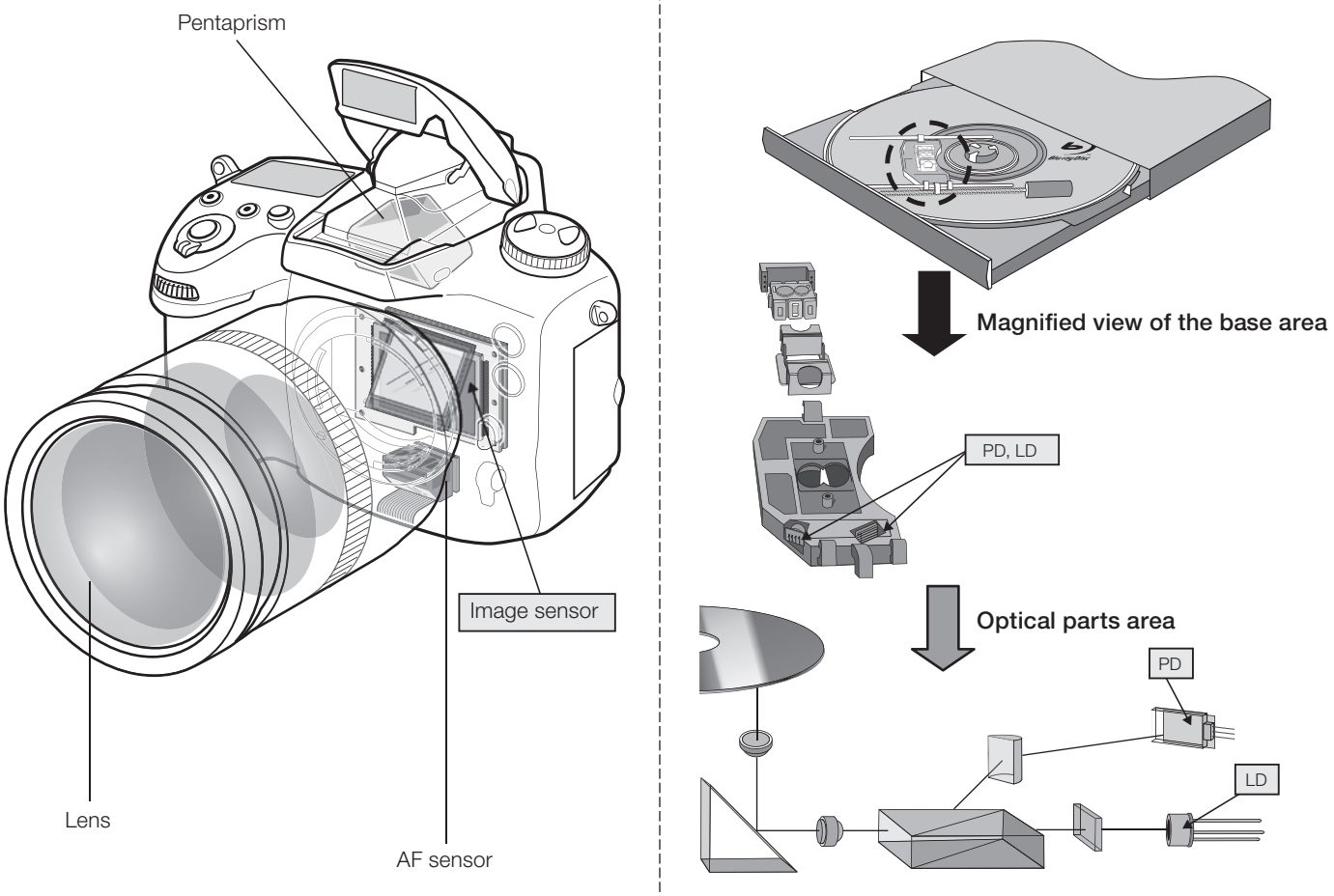


Fig. 2 Digital Camera and Optical Pickup Structure

3. Product Introduction (TB3036G, TB3038, TB3038B)

The features and properties of each of these adhesives are as follows (Table 1, 2; Fig. 3).

• TB3036G

Flexible with a low rate of contraction during curing. Bonds well with a variety of adherends such as metal and plastic.

These traits make it most suitable for parts where high adhesive strength with impact resistance is required.

• TB3038

Exhibits high adhesive strength for PPS, polycarbonate plastic, glass, metal and other materials that are difficult to bond to. Suitable for parts requiring high adhesive strength, a low curing contraction ratio and high hardness.

• TB3038B

Like TB3038, exhibits high adhesive strength for PPS, polycarbonate plastic, glass and metal. Additionally, the adhesive changes from blue to pale yellow when exposed to UV, allowing the level of exposure and Degree of curing to be visually confirmed.

Hardness, adhesive strength and visual confirmation performance vary per product, so choose the adhesive that best suits your application.

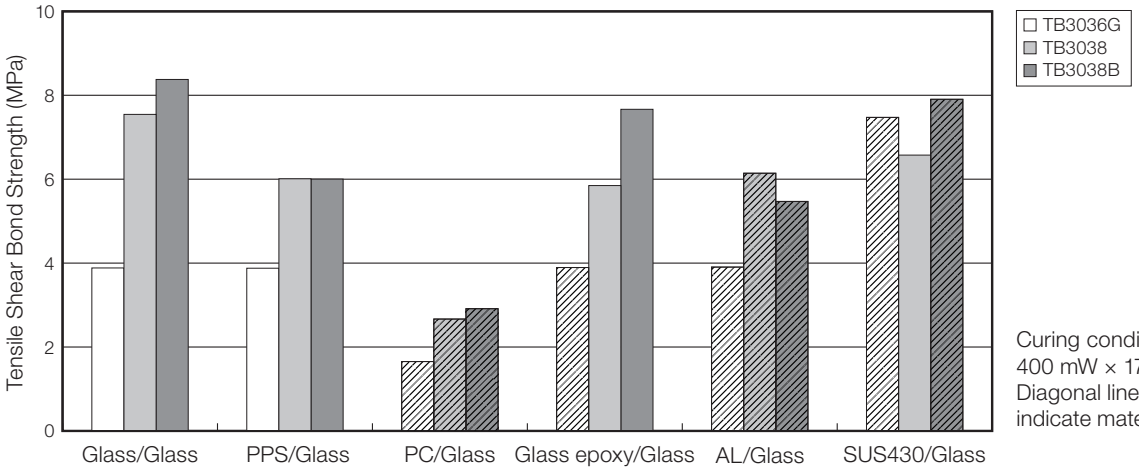
Table 1 Physical Characteristics

	Unit	TB3036G	TB3038	TB3038B	Testing method	Remark(s)
Appearance	-	White	White	Blue	3TS-2100-001	-
Viscosity	Pa·s	29.0	13.0	12.5	3TS-2F00-007	Shear rate 20.0s^{-1}
Specific gravity	-	1.53	1.56	1.56	3TS-2500-002	25°C

Table 2 Cured Material Characteristics

	Unit	TB3036G	TB3038	TB3038B	Testing method	Remark(s)
Hardness	-	D40	D70	D75	3TS-2B00-004	-
Rate of contraction when cured	%	2.0	2.2	3.0	3TS-2600-001	-
Thick film curing performance	mm	2.5	2.9	2.8	3TS-3160-001	-
Storage modulus (E')	Pa	2.4×10^{8}	3.3×10^{9}	3.3×10^{9}	3TS-4730-001	25°C

Curing conditions: UV-LED (365 nm) 400 mW × 17.5 sec



Curing conditions: UV-LED (365 nm)
400 mW × 17.5 sec
Diagonal lines in the bar graph indicate material failure

Fig. 3 Tensile Shear Bond Strength

4. Property Changes Due to Changes in Environment

As mentioned above, adhesives for image sensors and optical pickups must change very little when subjected to various environmental conditions. Generally, applying heat makes a substance softer and applying cold makes it harder. Repeated stretching and contraction due to heating and cooling generates stress in the adhesive interface which makes misalignment more likely.

As a result, adhesives for image sensors and optical pickups must change very little when subjected to various environmental conditions.

In this section we explain the results obtained when measuring property changes.

■ Dynamic viscoelasticity measurements

The typical allowable temperature for digital cameras and computers is from 40 to 80°C. Our design was created to reduce changes in elastic modulus within this temperature range.

The following results compare measurements of general light-curing adhesives and the products described in this article (Fig. 4).

• TB3036G

This is the softest of the three products introduced in this article, and the shallow line in the graph indicates very little change. Therefore, misalignment is suppressed while maintaining flexibility.

• TB3038, TB3038B

These have a higher Tg and elastic modulus than TB3036G. This is indicated by a high line on the graph. Because Tg is high, elastic modulus changes gradually.

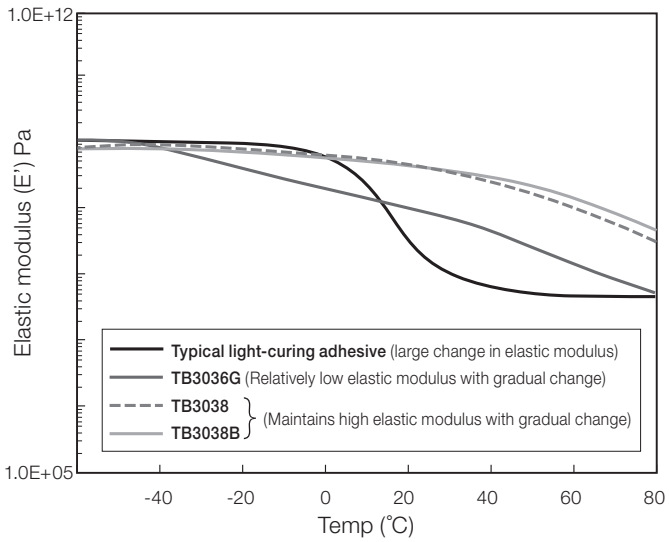


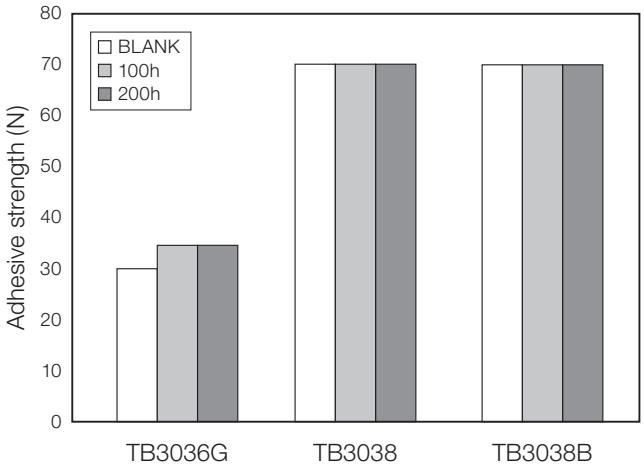
Fig. 4 DMA Measurements

These measurements indicate that, compared to typical light-curing adhesives, the elastic modulus of our products is affected very little in temperature changes and dramatic changes are unlikely to occur.

■ Reliability testing

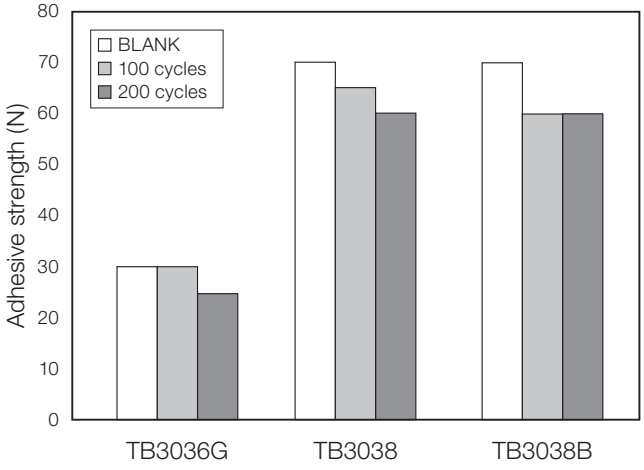
Digital cameras and computers are used in a variety of environments, so the adhesives used with them must also maintain adhesive strength, even under harsh conditions.

TB3036G, TB3038 and TB3038B show very little change of strength in high heat and humidity environments as well as environments with changes in heat, making them highly reliable light-curing adhesives (Fig. 5, 6).



Environmental conditions: 60°C 95% RH
Curing conditions: UV-LED (365 nm) 400 mW × 17.5 sec
Adherend: PPS

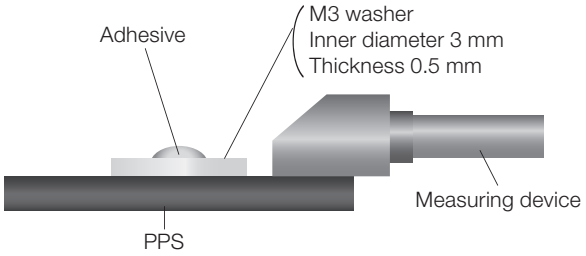
Fig. 5 High Heat and Humidity Test Results



Environmental conditions: -40°C to 80°C, 30 min. each
Curing conditions: UV-LED (365 nm) 400 mW × 17.5 sec
Adherend: PPS

Fig. 6 Heat Cycle Test Results

We measured adhesive strength through the methodology described below (Fig. 7).



1. Washer is placed on the PPS test piece.
2. Inside of the washer is filled with adhesive and cured.
3. Pressure is applied horizontally to the side of the washer using the measurement equipment. Adhesive strength determined as the strength required to cause peeling.

Fig. 7 Adhesive Strength Measurement Method

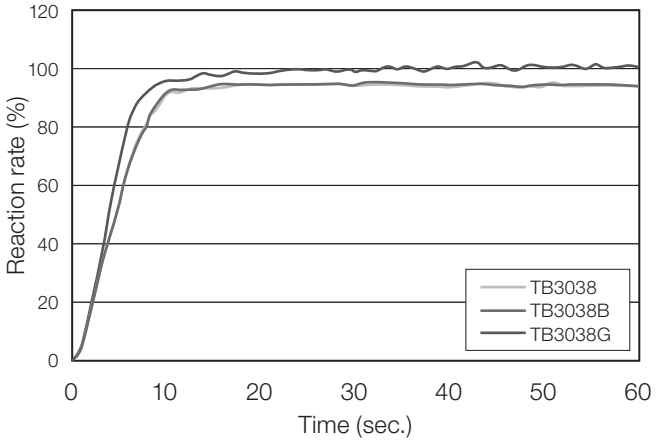
5. Reaction Speed, Outgassing, Environmental Performance

The three products introduced here cure quickly, have a high rate of reaction, demonstrate little outgassing and contain very little halogen and no organotin compounds.

■ Curing speed and reaction rate

Fast curing is required to reduce the time required for manufacturing processes. Additionally, a high reaction rate is required to keep large amounts of non-reactive components from causing misalignment or outgassing. The high reactivity of this group of products means that they will cure in well under a minute, even when cured with UV-LED (Fig. 8).

To measure curing speed, an FT-IR method was used in which results are checked from the peak change according to the particular functional group.



Light source: UV-LED (365 nm) 400 mW/cm²

Fig. 8 Curing Speed and Reaction Rate

■ Outgassing Volume

As current electrical/electronic products become thinner, the distance each of their parts is reduced, raising the likelihood of contamination of lenses and mirrors when adhesives generate gas. Even highly airtight designs are greatly affected by gas. This group of products was designed for low levels of outgassing.

Changes in weight in an 80°C environment indicate that outgassing volume is very low (Table 3).

Table 3 Outgassing Volume

	Unit	TB3036G	TB3038	TB3038B	Testing method
Outgassing Volume	%	0.7	0.5	0.5	3TS-4720-001
Heating residue		99.3	99.5	99.5	

Curing conditions: UV-LED (365 nm) 400 mW × 17.5 sec
Measuring conditions: 80°C for 2 hours after curing

■ Environmental performance

The values below indicate the amount of chlorine, bromine and organotin (not contained) contained in TB3036G, TB3038 and TB3038B (Table 4).

Table 4 Environmental Performance

	TB3036G	TB3038	TB3038B	Measurement method
Chlorine (ppm)	N.D.	N.D.	N.D.	Combustion method
Bromine (ppm)	N.D.	N.D.	N.D.	
Organotin	N.D.	N.D.	N.D.	GC/MS

N.D. = Not Detected
* Measured lower limit

6. UV Light Sources

UV-LED light sources can be used to cure these products. Differences in light sources are further explained below.

■ Wavelength distribution

Compared to mercury lamps, metal halide lamps and other devices that generate ultraviolet rays, UV-LED utilized here has a very narrow distribution of wavelengths, the wavelengths released are quite specific (Fig. 9).

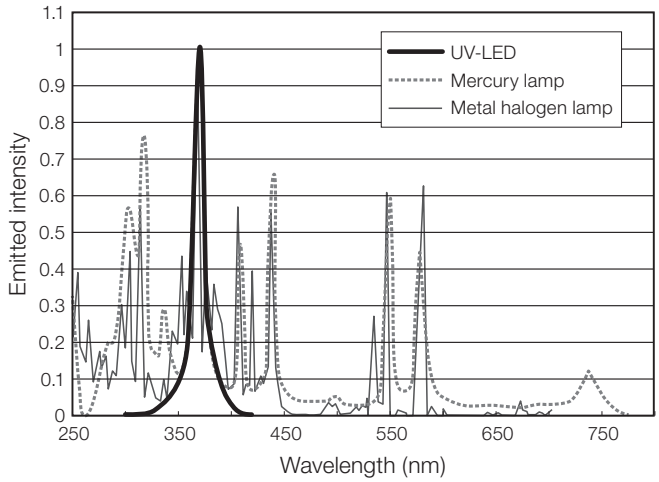


Fig. 9 Wavelength Distribution by Light Source

UV-LED is an ecological source because it generates little heat and is energy efficient. Another advantage is that high levels of brightness can be output with compact equipment. However, in order to use it as a light source for light-curing adhesive, the adhesive must be designed in accordance to the light source. This is because energy varies depending on the wavelength.

■ Light energy

In light energy, the shorter the wavelength, the higher the energy produced, as indicated by the formula below (Table 5). Additionally, when considering wavelength distribution of the light source in total, UV-LED demonstrates lower energy than other light sources.

$$E = h\nu = h \times \frac{C}{\lambda}$$

E : Energy
h : Planck constant
ν : Frequency of vibration
C : Light velocity
λ : Wavelength

Table 5 Energy Differences by Wavelength

	200 nm	300 nm	400 nm	500 nm
Energy (kJ/mol)	598	398	301	239

As mentioned above, because UV-LED is a low energy light source and there are issues regarding reactivity with conventional UV-curing adhesive, it is difficult to obtain high adhesive strength and suppress misalignment, so it was not used in areas requiring positional accuracy.

However, TB3036G, TB3038 and TB3038B are light-curing adhesives for image sensors and optic pickups that deliver high adhesive strength and suppress misalignment when cured with UV-LED.

Closing

We are proud to present TB3036G, TB3038 and TB3038B, our adhesives for image sensors and optical pickups. We are certain that image sensors and optical pickups will continue to become smaller and thinner, reducing the area for bonding and increasing the influence of curing contraction and susceptibility to heat. This means that a higher and higher level will be expected of light-curing adhesives.

Moving forward, we at ThreeBond will make every effort to meet these customer needs, continuing our development of light-curing adhesives that meet the next generation head on.

<References>
Technical News No. 45, Visible light-curing Resin
Technical News No. 76, Light-curing adhesives compatible with UV-LED Light Sources

ThreeBond Fine Chemical Co., Ltd. R&D Headquarters
Development Division 2, Electric Development Division 2
Yasunori Sakamoto
Sei Saito

ThreeBond TECHNICAL NEWS
ThreeBond Co., Ltd.
4-3-3 Minamiosawa, Hachioji,
Tokyo 192-0398
Tel: +81-42-670-5333