Heat curing – fast processes thanks to DELO®

One-component, heat-curing adhesives already contain a hardening component. However, this is thermally blocked so that the adhesive’s ingredients do not crosslink at room temperature.

Heat curing has always been a reliable curing mechanism for adhesives, but extremely short curing times have not been possible until now.

Due to our commitment to continuous development, DELO® has succeeded in perfecting the properties of heat curing, such as improved resistance to environmental influences, maximum reliability and fast cycle times in production. In addition, heat-curing adhesives are easy to process.

DELO®’s adhesives are suitable for every kind of application area, including microelectronics, mechanical engineering, semiconductors, and motor bonding.

**Flip-chip bonding**

- in just 6 s

**Motor bonding**

- in just 2 min
### Special advantages of DELO®'s heat-curing adhesives:

<table>
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<th>Advantages of heat curing</th>
<th>Your benefit</th>
<th>Page</th>
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<tr>
<td>Curing at low temperatures</td>
<td>Joining of temperature-sensitive components, greater freedom in component material selection</td>
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</tr>
<tr>
<td>Maximum reliability</td>
<td>Reliable functioning over the entire lifetime of the component</td>
<td>5</td>
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<td>High strength</td>
<td>High reliability of use and long lifetime</td>
<td>6</td>
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<tr>
<td>Innovative processes</td>
<td>Optimized production flow, strong market position</td>
<td>7</td>
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<td>High flexibility</td>
<td>Unique selling proposition for the end product, high reliability of use</td>
<td>8</td>
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<tr>
<td>Wide temperature range of use</td>
<td>Reliable functioning over the entire lifetime of the component</td>
<td>9</td>
</tr>
<tr>
<td>Fast fixation within seconds</td>
<td>Short cycle times, high output, low investment and unit costs</td>
<td>10</td>
</tr>
<tr>
<td>Excellent adhesion</td>
<td>High strength and long-term stability, reliable functioning</td>
<td>11</td>
</tr>
<tr>
<td>Miniaturization</td>
<td>Joining of tiny components that cannot be fixed mechanically</td>
<td>4, 8</td>
</tr>
<tr>
<td>Product types with second curing mechanism available</td>
<td>Flexibility for a wide range of technological design possibilities</td>
<td>4, 11</td>
</tr>
</tbody>
</table>

Adhesive colored magenta for illustration purposes
Optical components, such as lenses and image sensors, are precisely aligned using DELO DUALBOND®. The adhesive remains liquid during alignment. As soon as the component has reached the position for optimal image quality, the adhesive is quickly fixed within seconds by exposure to light using DELOLUX® LED curing lamps specifically adapted to this process. Subsequent final curing by heat proceeds at just +176 °F (+80 °C).

Technical properties of DELO DUALBOND®
- Fast fixation by UV light (less than 1 s @ 55 mW/cm²)
- Curing at low temperatures:
  - Final curing possible at +176 °F (+80 °C)
- Excellent adhesion to plastics, such as PBT, FR4, etc.
- Low outgassing, low shrinkage
- Good temperature stability
- Good resistance to climatic changes, humidity and in salt spray test
- Halogen-free according to IEC 61249-2-21

Advantages of heat curing

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Your Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimized production flow</td>
<td>Curing at low temperatures at just +176 °F (+80 °C) – makes it possible to bond temperature-sensitive materials</td>
</tr>
<tr>
<td>Increased production capacity</td>
<td>Reliable fixation in less than 1 s (depending on the component) for short cycle times</td>
</tr>
<tr>
<td>Process reliability</td>
<td>Stable, low shrinkage results in high yield rate and long lifetime</td>
</tr>
<tr>
<td>High efficiency</td>
<td>Low energy consumption</td>
</tr>
</tbody>
</table>

Illustration of the many bonding tasks of compact camera modules

Thanks to DELO DUALBOND®, it is now also possible to bond temperature-sensitive components and cure shadowed areas in a fast and highly reliable process. These adhesives are perfectly suited for the active alignment process by providing fast light curing with secondary temperature curing at only +176 °F. We often recommend that customers use DELO DUALBOND® adhesives because we know that they work without fail!

Andre By, Chief Technology Officer, Automation Engineering Incorporated
Chip-on-board encapsulation

Electronic components, such as chips and sensors, must work under extreme environmental conditions in various application areas. Sensors that control the oil level or oil pressure, for example, must be highly resistant to both aggressive media and elevated temperatures. Especially for these requirements, encapsulants with anhydride-curing epoxy resin bases with outstanding media and temperature resistance have been developed.

Technical properties of DELO® MONOPOX GE *
- Used as Dam & Fill or glob top
- Very low coefficient of expansion (11 – 25 ppm/K)
- Temperature of use from –85 °F to +482 °F
  (–65 °C to +250 °C)
- Excellent media resistance to, i.e. diesel, oils, greases
- Good humidity resistance
- Variable curing parameters: Fast curing or low curing temperatures possible
- Halogen-free products available acc. to IEC 61249-2-21
- Products for fast light-fixation available

* GE = General Encapsulant

Advantages of heat curing

<table>
<thead>
<tr>
<th>Advantages of heat curing</th>
<th>Your benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum reliability</td>
<td>Reduction of thermo-mechanical tensions through low CTE; excellent media and temperature resistance; temperature of use of HT products up to +482 °F (+250 °C); reliability qualification according to JEDEC MSL 1</td>
</tr>
<tr>
<td>Optimized processing</td>
<td>Steady dam material for defined casting pattern; excellent flow properties of the fill material without substrate heating</td>
</tr>
<tr>
<td>Increased production capacity</td>
<td>Curing at +302 °F (+150 °C) in 20 min; dam stacking without intermediate curing steps; curing of dam and fill in one step</td>
</tr>
</tbody>
</table>

DELO®s highly reliable encapsulants allow curing of both Dam and Fill in just one step. Expensive intermediate steps are omitted and production capacity is increased. This is a definite benefit to us.

Michael Walsh MPhys, Technical Lead / R&D, Xaar Technology Ltd

Maximum reliability – further examples:
- MEMS die attach for oil pressure sensors
- Large-area encapsulation of PCBs
Bonding in electric motors

Increasing demands on electric motors in a broad variety of application areas are also boosting the design-related requirements on the bonded connections of individual motor components. The key principle for the development of the latest generation of electric motors is a compact and efficient design. DELO® has developed a powerful product range especially to address these bonding challenges.

Technical properties of DELO® MONOPOX
- High strength
- High impact resistance
- Low shrinkage
- Gap-filling
- High media and temperature resistance up to +428 °F (+220 °C)

Advantages of heat curing

<table>
<thead>
<tr>
<th>Advantages of heat curing</th>
<th>Your benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased reliability of use and longer lifetime</td>
<td>High strength for reliable functioning even after years of use</td>
</tr>
<tr>
<td>Maximum reliability</td>
<td>High functionality even when subject to aggressive media and elevated temperatures</td>
</tr>
<tr>
<td>Optimized processing</td>
<td>Efficient dispensing thanks to gap-filling properties; short cycle times by induction curing</td>
</tr>
</tbody>
</table>

We use DELO® adhesive in our compact angle grinder where the requirements in terms of adhesion and temperature resistance are very high. We chose DELO® MONOPOX because it offers the most suitable properties for these complex conditions compared with other adhesives.

Michael Schmohl, Head of R&D Motors, Metabowerke GmbH
Conductive bonding of microelectronic components

Microelectronics production is placing an ever-growing importance on components being attached to a substrate with the highest reliability. When the component is placed onto the printed circuit board by a machine, it must not shift or float during later movement of the assembly or final curing. For this purpose, DELO® supplies specially designed adhesives that can be fixed by light and subsequently cured by heat.

Heat curing = Innovative processes

Technical properties of DELO DUALBOND® IC *
- Very fast light fixation strength in 0.2 s
- Curing at low temperatures from +176 °F (+80 °C)
- Excellent adhesion to plastics, gold, silver, and silicon
- Low shrinkage
- Low outgassing

* IC = Isotropic Conductive

Advantages of heat curing | Your benefit
---|---
Optimized processing | Fast fixation by light within 0.2 s prevents the components from shifting or floating on the PCB, and enables short cycle times
Reliable functioning | Miniaturization of the components results in improved optical properties of the IR sensor components
Maximum reliability | Reliably passes consumer test requirements

Innovative processes – further examples:
- Chip attach
- Bonding of IR housing
- Lens bonding

DELO DUALBOND® enables reliable placing, precise positioning and fast, high-strength adhesive curing. DELO® fulfills these key criteria for the increasing requirements of chip bonding!

Dr. Hugo Pristauz, VP Flip Chip, Besi Switzerland AG
MEMS packaging

Microelectromechanical systems (MEMS) are found in many everyday products. In particular, mobile phones and automotive assemblies contain numerous MEMS elements, such as pressure sensors or accelerometers. Adhesives for MEMS packaging must overcome unique challenges. Particularly when bonding the MEMS chip to the substrate, high flexibility and high strength of the adhesive is required. It is essential that tensions on the MEMS structures, such as those arising from temperature changes for example, are relieved and associated changes in signal characteristics prevented.

Technical properties of DELO® MONOPOX DA*
- High flexibility
- High die shear strength
- No embrittlement after thermal stress
- Easy to process
- Precise dispensing
- Curing at low temperatures possible: +176 °F (+80 °C)

* DA = Die Attach

<table>
<thead>
<tr>
<th>Advantages of heat curing</th>
<th>Your benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best function</td>
<td>Reduction of thermo-mechanical tensions through highest flexibility and curing at low temperatures</td>
</tr>
<tr>
<td>Increased production capacity</td>
<td>Fast curing, i.e. 15 min at +266 °F (+130 °C)</td>
</tr>
<tr>
<td>Maximum reliability</td>
<td>No embrittlement after thermal stress; highest die shear strength</td>
</tr>
</tbody>
</table>

High flexibility – further examples:
- Bonding in electric motors
- Die attach
- Cap bonding

Microelectromechanical system
Magnetic rings are bonded in the 8HP 8-speed transmission of the ZF Friedrichshafen AG (see figure below)

Bonding magnet rings for automatic transmissions

Saving CO₂ emissions and lowering fuel consumption; these demands on the automotive industry are ever growing. By saving material and fuel, modern transmissions can contribute to a more environmentally friendly way of driving. For the 8HP 8-speed transmission made by ZF Friedrichshafen AG, magnetic rings are used. DELO® MONOPOX bonds a plastic-infused magnetic ring to an aluminum retaining ring to form a transducer ring system.

Technical properties of DELO® MONOPOX
- Excellent adhesion to metals, ferrites, magnets and many technical plastics
- Very high strength, even at elevated temperatures
- Resistance to media, humidity and vibrations/shocks
- Wide temperature range of use from –67 °F to +392 °F (–55 °C to +200 °C)
- High run resistance even during heat curing

<table>
<thead>
<tr>
<th>Advantages of heat curing</th>
<th>Your benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple solution</td>
<td>Bonding is the perfect joining method; due to their brittleness, it is not possible to directly connect the magnetic rings to the transmission components. Therefore, they are bonded to a retaining ring</td>
</tr>
<tr>
<td>Optimized production flow</td>
<td>Easy, reliable assembly of the magnetic ring in the transmission in a fully automated production process</td>
</tr>
<tr>
<td>Maximum reliability</td>
<td>Reliably passes all automotive tests; permanent use of the magnetic rings at temperatures between –40 °F and +356 °F (–40 °C and +180 °C) and at speeds up to 10,000 revolutions per minute</td>
</tr>
</tbody>
</table>

Transducer ring system of MS-Schramberg for the 8HP 8-speed transmission of ZF Friedrichshafen AG (see figure above)

For us, heat curing is the key to a permanent and reliable connection. Bonding technology is the ideal method for joining the magnetic ring to the retaining ring. Therefore, bonding with DELO® is not an alternative, but our first choice.

Dietmar Schweger, Head of Product Development & Sales, MS-Schramberg
Flip-chip bonding

Flip-chips are equipped with electrical connectors directly at the bottom so that they have very small footprints and offer cost benefits in production and later processing. With DELO® MONOPOX AC adhesives, flip-chips (such as those on RFID labels) are reliably electrically contacted and mechanically connected in seconds.

Technical properties of DELO® MONOPOX AC*
- Fast thermode curing in seconds
- Permanent electrical reliability
- Universal adhesion to PET, Al, Cu, Si, Au, paper
- Suitable for needle dispensing (250 µm) and jetting of small adhesive quantities (less than 0.03 mg)

* AC = Anisotropic Conductive

Advantages of heat curing

<table>
<thead>
<tr>
<th>Advantages of heat curing</th>
<th>Your benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>High production capacity</td>
<td>Increased production output thanks to curing within seconds results in low investment and unit costs</td>
</tr>
<tr>
<td>Reliability of use</td>
<td>Optimal solution for products with a long lifetime and broad range of use; function is ensured</td>
</tr>
<tr>
<td>High process reliability</td>
<td>Maximum yield rates (&gt; 99.9 %) thanks to optimized particle mixtures; excellent reproducibility even of extremely small dispensing quantities by jetting</td>
</tr>
<tr>
<td>More flexible production</td>
<td>Multi-purpose adhesive for various substrates and chips enables short changeover times and fast process adaptation</td>
</tr>
</tbody>
</table>

When bonding flip-chips, short cycle times of less than 10 seconds are decisive for clearly reducing the unit costs and increasing the production volume. DELO®’s comprehensive support enabled us to successfully implement our project.

Dr.-Ing. Frank Kriebel,
Director Advanced-Development
SMARTRAC Technology GmbH

- Smart card die attach
- LED die attach
- Heat pulse process
Printed circuit board – SMD assembly, PCB embedding

1) DELO® MONOPOX SMD assembly adhesives are multi-purpose for a broad variety of substrates. Thanks to curing at low temperatures (approx. +176 °F [+80 °C]), these adhesives can also be used for temperature-sensitive substrates.

2) When embedding PCBs with DELO DUALBOND® mCD, the components are light-fixed in less than 1 second immediately upon placement onto the copper plate. As a result, the necessary placement accuracy is also maintained during handling down the line. During the in-line process, the adhesive is later heat-cured at low temperatures.

Technical properties of DELO® MONOPOX
- Universal adhesion
- Highly reliable fixation of MELFs (Metal Electrode Leadless Faces)
- Very good wet strength
- Low extractable ion content: Na⁺, K⁺ below 10 ppm

Technical properties of DELO DUALBOND® mCD *
- Halogen-free according to IEC
- Preliminary fixation by UV light (320 – 400 nm) in 1 to 5 s; heat curing at +176 °F to +266 °F (+80 °C to +130 °C)
- CTE adjustable by filler content (more than 60 ppm)

* mCD = modified polycarbamin acid derivatives

<table>
<thead>
<tr>
<th>Advantages of heat curing</th>
<th>Your benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>High efficiency</td>
<td>Curing during wave soldering, reflow or laminating processes saves additional curing steps</td>
</tr>
<tr>
<td>Reliable processing</td>
<td>Fast curing and low curing temperatures possible; easy dispensing</td>
</tr>
<tr>
<td>Innovation</td>
<td>Fast fixation by light in less than 1 s possible with DELO DUALBOND®</td>
</tr>
<tr>
<td>Reliable functioning</td>
<td>High strength and long-term stability</td>
</tr>
</tbody>
</table>

The DELO DUALBOND® adhesives enable us to fix our components directly after placing them onto the copper plates. This prevents shifting of these components during further processing steps of the PCBs. Heat curing proceeds in the line in an oven at +266 °F to +302 °F.

Jürgen Wolf,
Assistant Manager Research & Development,
Würth Elektronik GmbH & Co. KG

Excellent adhesion – further examples:
- Sensor casting
- MEMS
### Chemical basis

<table>
<thead>
<tr>
<th>Curing</th>
<th>aminic</th>
<th>mCD</th>
<th>acrylic</th>
<th>cationic</th>
<th>anhydride</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 to 8 s @ +338 to +392 °F (+170 to +200 °C) *</td>
<td>3 to 8 s @ +302 °F (+150 °C) *</td>
<td>1 to 5 s @ +356 °F (+180 °C) *</td>
<td>2 min @ +302 °F (+150 °C) ***</td>
<td>20 to 30 min @ +302 °F (+150 °C) ***</td>
<td></td>
</tr>
<tr>
<td>15 to 60 min @ +248 to +302 °F (+120 to +150 °C) ***</td>
<td>5 to 10 min @ +212 °F (+100 °C) ***</td>
<td>10 to 20 s @ +212 °F (+100 °C) ***</td>
<td>3 to 5 min @ +266 °F (+130 °C) ***</td>
<td>90 min @ +257 °F (+125 °C) ***</td>
<td></td>
</tr>
</tbody>
</table>

### Properties

<table>
<thead>
<tr>
<th>aminic</th>
<th>mCD</th>
<th>acrylic</th>
<th>cationic</th>
<th>anhydride</th>
</tr>
</thead>
<tbody>
<tr>
<td>excellent media resistance</td>
<td>fast-curing curing at low temperatures</td>
<td>tension-equalizing fast-curing flexible</td>
<td>good adhesion to gold and silver</td>
<td>good media resistance</td>
</tr>
<tr>
<td>high strength even at elevated temperatures</td>
<td>good thermal conductivity</td>
<td>low corrosion</td>
<td>high reliability</td>
<td></td>
</tr>
<tr>
<td>good temperature resistance</td>
<td>good adhesion to metals (e.g. Al, steel, Au)</td>
<td>low ion content</td>
<td>good temperature resistance</td>
<td></td>
</tr>
</tbody>
</table>

### Applications

<table>
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<tr>
<th>Electric motors</th>
<th>Camera modules</th>
<th>RFID</th>
<th>Die attach</th>
<th>Dual interface card</th>
<th>Chip-on-board encapsulation (Glob top, Dam &amp; Fill)</th>
<th>MEMS die attach</th>
<th>PCB</th>
<th>Magnet bonding</th>
<th>Structural bonding</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓ (ACA, ICA, NCA)</td>
<td>✓ (ACA, ICA, NCA)</td>
<td>✓ (ACA, NCA)</td>
<td>✓ (ACA, ICA, NCA)</td>
<td>✓ (ACA, ICA, NCA)</td>
<td>✓</td>
<td>✓ (dual-curing)</td>
</tr>
</tbody>
</table>

* Thermode curing
** In air convection oven with nitrogen
*** In air convection oven
In order to better utilize the advantages of heat-curing in production, including resistance, maximum reliability and fast processes, DELO® has developed complementary dispensing technology, such as the DELO-DOT® PN3 jet valve and DELO® FLEXCAP®.

DELO-DOT® PN3 microdispensing valve – Precise, compact and light-weight

The pneumatic DELO-DOT® PN3 microdispensing valve is precise, fast and compact. It has an operating frequency of up to 330 Hz (drops per second). This unique system is made to be robust due to its modular design. This design allows the dispensing valve to be easily disassembled into its single parts. The fluid system is strictly separated from the actuator. This avoids time-consuming cleaning, and the valve can be put into operation again quickly. The actuator has an extremely long lifetime of more than 1 billion cycles.

DELO® FLEXCAP® with integrated fill level sensor in the pressure tank

A flexible, hermetically tight foil replaces the conventional cartridge piston. As a result, adhesives can be stored, transported and dispensed without bubbles. The cartridge system which is free of trapped air enables the highest dispensing reliability, precision and maximum emptying. DELO® FLEXCAP® is available in 10 ml and 30 ml container. The fill level sensor of the pressure tank for DELO® FLEXCAP® provides benefits for fully automated production. Integrated sensors transmit a signal that indicates when the cartridge is nearly empty and again when it is completely empty. As a result, the user can prepare a new cartridge in time to minimize downtime.

Advantages at a glance:
- Process reliability thanks to bubble-free dispensing
- Reproducible processes with a high yield rate
- Easy to integrate into every production system
- Cost savings through reduced waste, minimized downtime, and maximum emptying of the cartridges
- The air-tight cartridge enables easy and cost-efficient transport
We pave the way to your success

We support our customers from the earliest product development phase, help them integrate our products in their manufacturing processes, and provide support during ongoing production whenever required. In addition, DELO® has a large network of partners. We collaborate with them extensively and work for your success.

Your contacts for process design

Your contacts for adhesive dispensing
Introduction
- Joint determination of process specifications based on the prototype phase results
- On-site process and start-up consulting

Production
- Ongoing intensive customer support during production
- Process finetuning where necessary
- Support of quality assurance

Ongoing support
- Global support
- Adapt to process changes
- Assist the customer in improving process efficiency
- Application-specific training

Adhesive heat curing

Ovens
The adhesive is heated and cured by warm ambient temperatures in the oven. For a steady curing progress, air convection ovens should be preferred. Tunnel ovens enable cost-efficient in-line thermal processes.

Application examples:
- Bonding in compact camera modules (page 4)
- Chip-on-board encapsulation (page 5)
- Bonding of microelectronic components (page 7)
- MEMS packaging (page 8)
- SMD assembly, PCB embedding (page 11)

Heated stamps/thermodes, presses, heating elements
The heat required for adhesive curing is transmitted to the component to be bonded through direct, punctiform contact. For this purpose, heated plates, pliers, grippers or (multiple) stamps are used. The heat is conducted to the adhesive and triggers fast curing in seconds. The thinner the component and the adhesive layer, the better the heat transfer and the faster the curing process. This type of curing is especially suitable for in-line processes.

Application examples:
- Flip-chip bonding (page 10)
- Bonding of friction linings

Induction
Electrically conductive components are inductively heated up to +356°F (+180°C) in seconds. Therefore, the adhesive is quickly cured (sometimes in less than 1 min). Induction systems consist of a voltage generator and a coil surrounding the component. Via a pyrometer, a thermal control system can be installed. The precision of the pyrometer measurement is influenced by the surface properties (for example, color, degree of reflection, roughness).

Application examples:
- Bonding magnetic rings for transmissions (page 9)
- Bonding slot magnets
- Bonding in electric motors (page 6)

Infrared radiators
IR radiators are used in curing ovens. However, they can also be externally integrated into the bonding process. Very large areas are cured by IR panels – small, selective areas are cured by spot radiators without heating the whole component.

Application examples:
- Chip-on-board encapsulation (page 5)
- SMD assembly, PCB embedding (page 11)

Your contacts for adhesive curing
The data and information provided are based on tests performed under laboratory conditions. Reliable information about the behavior of the product under practical conditions and its suitability for a specific purpose cannot be concluded from this. It is the customer’s responsibility to test the suitability of a product for the intended purpose by considering all specific requirements and by applying standards the customer deems suitable (e.g., DIN 2304-1). Type, physical and chemical properties of the materials to be processed with the product, as well as all actual influences occurring during transport, storage, processing and use, may cause deviations in the behavior of the product compared to its behavior under laboratory conditions. All data provided are typical average values or uniquely determined parameters measured under laboratory conditions. The data and information provided are therefore no guarantee for specific product properties or the suitability of the product for a specific purpose. Nothing contained herein shall be construed to indicate the non-existence of any relevant patents or to constitute a permission, encouragement or recommendation to practice any development covered by any patents, without permission of the owner of this patent. All products provided by DELO are subject to DELO’s General Terms of Business. Verbal ancillary agreements are deemed not to exist.

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