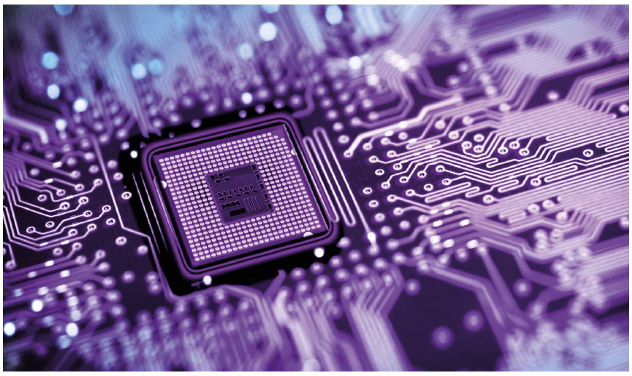
WHITE PAPER

NETZSCH

UV Cure Monitoring of Paints and Adhesives



1 UV-cured coatings for electronic components

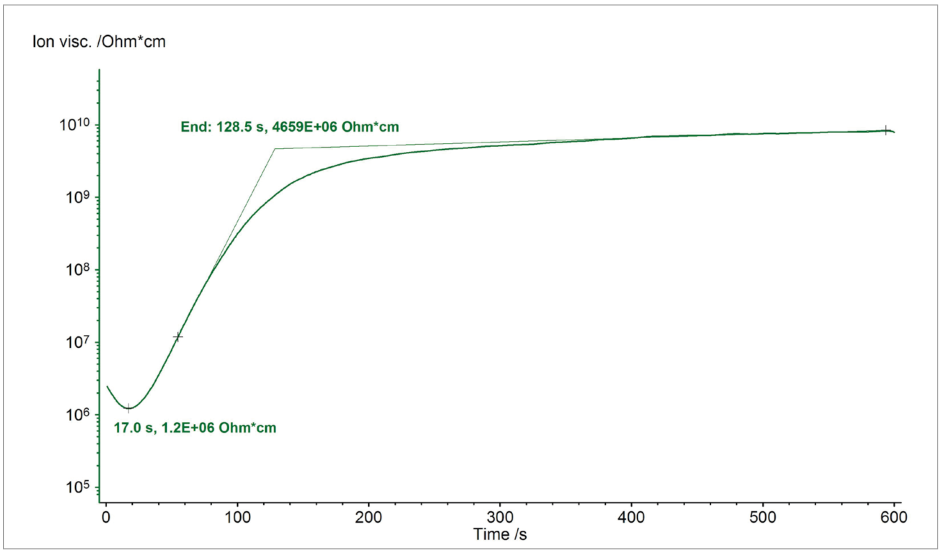
Ultraviolet (UV) light curing is a technology being applied increasingly in the fields of paints, inks, coatings, sealants, adhesives and dental composites. 1-component free radical UV systems such as acrylates can cure within some tenths of a second at room temperature. 1- or 2-component cationic epoxy resins exhibit a curing time ranging from just seconds to a few minutes. The advantages of UV resin systems are evident: Their high speed translates to high throughput, they have a low energy requirement (no heating is needed), and the lack of solvents eliminates ecological concerns.

Cure Monitoring by Dielectric Analysis (DEA) – Method and Instrumentation

Dielectric Analysis (DEA), as per ASTM E 2038 and E 2039, allows for the measurement of changes in the dielectric properties of a resin during UV curing. The liquid or pasty resin must be placed in direct contact with two electrodes comprising the dielectric sensor. A sinusoidal voltage (excitation) is applied and the resulting current (response) is measured, along with the phase shift between voltage and current. These values are then used to determine the ion mobility (ion conductivity) and the alignment of dipoles. In turn, the dielectric properties of permittivity ε′ and loss factor ε″ are calculated from these effects. Of primary interest with regard to curing is the ion viscosity. This is the reciprocal value of the ion conductivity, which is proportional to the loss factor.
Use of the DEA technique is not limited to the lab environment; it can also be applied to in-situ curing in a mold or on a conveyor under processing conditions. For production monitoring and process control, a specific ion viscosity value can be programmed to trigger de-molding of a part or coating once it is sufficiently cured. This reduces cycle times and increases throughput, thereby lowering costs and potentially allowing lower prices to be charged for the finished product.

A variety of questions may arise during the UV curing process. How long does it take for the resin to begin UV curing? How high is the reactivity? How effective is the photo initiator? When is curing complete? How can the curing cycle be optimized? Is there any potential for post-curing?

The answers to questions such as these can be investigated by using Dielectric Analysis (DEA), which is commonly used for the thermal curing of thermosetting resins – not only in the laboratory environment, but also in-situ, i.e. in-process.



2 DEA measurement result for the UV curing of a flexible sealant based on a 1-component epoxy

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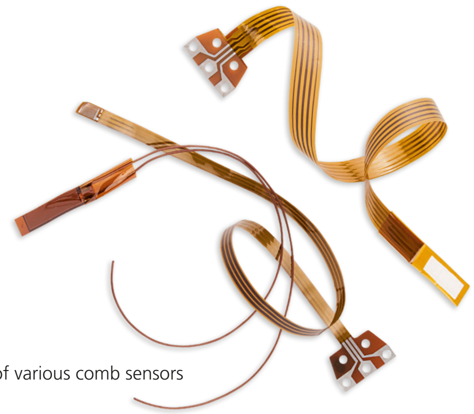
Figure 2 depicts the UV curing of a sealant based on a 1-component epoxy resin which is used for the protection of organic LEDs. The liquid resin was applied with a thickness of approx. 200 µm to the surface of the disposable IDEX ("interdigitated electrode") comb sensor. The measuring frequency was 1000 Hz at room temperature. An irradiation intensity of 55–60 mW/cm² was achieved by using a high-pressure mercury UV lamp. The irradiation time amounted to 60 s.

Initially, the ion viscosity drops due to the input of heat by the UV lamp. The evaluated minimum after 17 s corresponds to the lowest viscosity and therefore the best flow behavior and best wetting of a substrate. UV curing begins immediately thereafter, with an increase in ion viscosity of nearly four orders of magnitude. The slope of this high increase correlates with the high reactivity of the epoxy (curing speed). After approx. 300 s, the ion viscosity curve levels out, signaling that curing is practically completed.

3 New versatile DEA 288 *Epsilon* (lab version) with up to 8 channels

4 New slim version of the DEA 288 *Epsilon* with up to 2 channels



5 Selection of various comb sensors

DEA 288 *Epsilon* – One Modular Concept to Meet Your Needs

The modular concept of the brand-new DEA 288 *Epsilon* allows for the study of the UV curing behavior of adhesives, paints, inks and coatings in nearly any application. The lab version (fig. 3) with up to 8 channels can be used in conjunction with a newly designed furnace for research and development, which has access to a triggered UV lamp via a light guide. The industrial versions are intended for production monitoring and process control, and are designed with up to 16 channels. As an example, figure 4 shows the slim version with up to two channels. The industrial devices are connected via rugged extension cables and connectors to various sensor types which are located in molds, ovens, conveyors or other devices for UV curing.

Reusable tool mount sensors (TMS) in a variety of geometries and temperature/pressure ranges can be applied to molding processes and dental composites. For paints, inks, adhesives and coatings, various implantable (disposable) comb sensors are available (fig. 5), tailored to a variety of application needs via defined electrode spacing from 1 µm to 115 µm.

DEA 288 *Epsilon* – At a Glance

- Modular concept for the laboratory (R&D) and/or for production processes
- Simultaneous multi-channel cure monitoring (versions with up to 2, 8 or 16 channels)
- Multi-frequency scans (from 1 mHz to 1 MHz)
- Extremely fast data acquisition time (<5 ms)
- A variety of reusable in-process TMS sensors
- A variety of disposable comb sensors
- New *Proteus*® software for controlling a press, an oven or a UV lamp

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NGB · White Paper – DEA_2 · EN · 10/11 · Technical specifications are subject to change.