UV LED Curing for Micro Speaker Manufacturing

The small electronics segment (mobile phones, tablets, personal computers, Bluetooth headsets, etc.) is a $6B global market. End consumers expect crystal-clear sound in various environments (while driving, outdoors, windy days, airports, through earpieces, etc.). To meet customer demand, speaker producers are turning to new manufacturing methods to enable higher volume manufacturing while increasing yields. This has led many implementing UV curing of adhesives or coatings for their production lines. And as a further advancement, UV LED systems are replacing traditional mercury systems due to their improved yields and increased throughput.

Figure 1: Consumer Electronics

Background

Electronic speakers have been transformed by a consumer industry that demands higher fidelity and ever-smaller packages. Mobile phones have migrated to smartphones using up to four speakers in a single phone to aid with noise-canceling technology. Tablets have overtaken PCs for mobile computing and the advent of on-line social games increases the need for high-quality audio performance. As these devices have become smaller, driving higher currents (which are required to produce the deep bass requested from consumers) is in conflict with small speaker sizes. Think back to the days when high-end audio speaker systems had one meter tall speakers to provide rich, wide-ranging sound. Today, consumers demand high-quality sound from a speaker less than 4 cm^2.

Manufacturers have followed these trends by moving from manual product lines to today's semi-automated. The next step is to move to fully-automated lines where process control and stability are required to reach the volumes and quality customer's demand.

Figure 2: Micro Speaker

Micro Speaker Overview

The basis of a speaker is the diaphragm (typically made from mylar, paper, or metal) that vibrates when electronic current is applied. This current is provided with wires (sometimes called a spider or coil) attached to a source that has converted digital signals into analog signals for pushing out over the airwaves. Holding it all together is a frame that is used to adhere the speaker to the electronic device. Figure 3 shows this basic structure.

Figure 3: Basis of a speaker

The process of creating an electronic speaker is complex and involves many steps. Most manufacturers have proprietary processes they have developed over many years to provide unique capabilities. However, using the speaker basics as a background, a simplified process is outlined in figure 4.

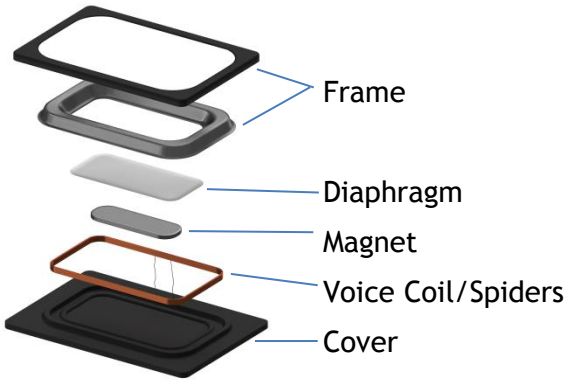

Figure 4: Assembly of a Speaker

The diaphragm is attached to the voice-coil. Since the diaphragm is sensitive, care must be taken to not have excessive heat that would lead to weakening and reduced quality. That assembly is then attached to a frame. The adhesive dispensing systems applies a specific amount of un-cured acrylate adhesive into specific areas or channels for curing. After each curing step a quality check happens to minimize scrap and waste further in the assembly process.

Even in this simple overview, it is clear that improperly cured material will impact the speaker performance. Under-cured material will not provide the correct adhesion while over-cured material will cause the adhesive to become hard, brittle and crack under stress, which has reduced acoustic performance leading to a future product returns by an unsatisfied consumer.

UV LED Curing

There are two primary benefits to utilizing UV LED curing in the micro speaker process. First is improved yield. The second is improved throughout. We'll examine each in turn.

Yield (defined as the number of salable, good units as a percentage of total units produced) is critical in high volume manufacturing. Assuming a vendor can product 5,000 speakers per hour, a 24x7 operation for 50 weeks could produce 42M speakers on a line. A .1% yield increase from 98% to 98.1% would be worth 42K speakers annually. At the competitive prices micro speakers are offered, these extra 42K speakers could provide significant profit margin to the vendor or allow them to gain market share from their competition.

Figure 5: UV Light Source

Yield is improved with UV LED curing systems by providing consistent UV output over long periods of time which lead to process stability. Figure 6 below shows output from a UV LED lamp covering an area the size of a micro speaker. As shown, the speaker material receives a homogenous dose of UV energy consistently across the surface with no “hot” spots or “dead” spots which would lead to a rejects.

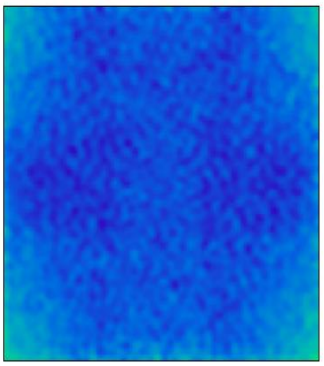

Figure 6: Consistent UV Output

Additionally, UV LED systems provide that stable output over long periods of time, typically greater than 20,000 hours. At the low power levels needed for micro speaker manufacturing, it is conceivable that the UV LED systems would last beyond 40,000 hours with the only maintenance being monthly checks of air filtration and ensuring the emitting window is clean.

The consistent output and long life lead to process stability, a key requirement for high-volume manufacturing. Knowing the equipment is producing the same UV output yesterday, today, and in the future allows the vendor to focus their resources on other parts of the manufacturing process. Process stability is further aided by the fact UV LED systems only produce output in the UV-A range, typically 365nm to match with the acrylic adhesive being used. Since no UV-C or infrared is being produced, the adhesive and surrounding transport are only receiving the amount of dose in the wavelength required. This UV LED ‘cold cure’ again improves process stability by not damaging the transport or other critical speaker components while the UV adhesive is being cured.

The second improvement of UV LED curing is increased throughput. In our above example, reducing the time of curing from 6 seconds to 4 seconds could improve throughput up to 30%, assuming the UV curing section is a bottleneck in the process. This improvement in throughput can come via two capabilities. First, as stated above, the ‘cold’ curing of the adhesive means the following verification step can be done immediately after curing and not time is lost in waiting for the transport or speaker to cool down before being tested. Additionally, the verification stage will have improved accuracy since the UV LED output is stable which leads to a more consistent cure for testing.

Since UV LEDs provide energy in a narrow band, an optimized wavelength adhesive can be used which can be optimized for shortened curing times. The adhesive manufacturer can depend on UV LED’s consistent output at a specific wavelength to develop a formulation which is highly reactive to the UV energy and thus shorten the curing time. Future developments of UV adhesives may also mean less adhesive is use for each speaker leading to an additional cost savings to the manufacturer.

Summary

Micro speaker manufacturers are under constant pressure to produce high-quality products in increasing volumes at lower prices. UV LED curing systems help them meet those goals by increasing yields and throughput. The basic elements of UV LED curing are combined to provide leading edge manufacturers a competitive advantage.