Fuel Cell Production Revs Up

The paste printing platform and process has other uses, too.

Unless you've been living under a rock the past several years, you are no doubt keenly aware of the global drive toward alternative energy sources. Certainly this initiative is attractive because of the clear environmental benefits of developing fossil fuel substitutes, but also because of the potential economic benefit. Although fuel cell technology has been proven viable for various applications, the production costs still remain relatively high, and further process development to promote low-cost, high-volume manufacturing is required to reach a price point that encourages widespread consumer acceptance.

Enter screen printing technology. As I've discussed in the past, printing processes employed for mainstream SMT and semiconductor packaging applications have endless possibilities beyond the realm of PCBs and BGAs. Fuel cell production is one such application where we can lend the materials deposition expertise that has been perfected in traditional electronics manufacturing to a new product, thus enabling the same accuracy, repeatability and speed advantages currently enjoyed by assembly and packaging firms.

Screen printing is a natural fit for fuel cells.

The three primary fuel cell technologies with which our company has been involved are solid oxide fuel cells (SOFCs) used mainly in small-scale power applications; proton exchange membranes (PEMs) found predominantly in the automotive space; and direct methanol fuel cells (DMFCs) used in battery replacements for portable devices. Most recently, our process development work has centered on SOFCs and PEMs. From a process perspective, many standard screen-printing principles apply for these fuel cell applications.

For both SOFCs and PEMs, the production method involves printing a consistent layer of material – often perfluorocarbon sulfonates (PFSA) or platinum/carbon/ionomer catalysts – onto a substrate. The substrates are of varying material types and different porous properties; knowledge of substrate properties and ink material behavior is tantamount to a robust process. Principal process control parameters for fuel cell manufacture are ensuring that the inks deposited have a uniform thickness across the entire printable area and making sure the deposit is absent of voids or pin holes, as these defects can hamper performance issues and often cause catastrophic failures by permitting uncontrolled mixing of hydrogen and oxygen.

Although material thickness is not a key component of the proper function of the fuel cell, it is important because of the high cost of platinum loaded inks. Consider that the raw cost of platinum is $1,105 per ounce and you get a picture of the expense of these materials. Clearly, then, depositing the material as thinly as possible – usually in the range of 12 to 20 µm – without sacrificing coverage control, is a key element to keeping costs down. With screens engineered specifically for fuel cell material control, inks developed for the screen printing process and the right printer platform, fuel cells can be manufactured for modern alternative energy devices.

As with any process, once the accuracy and repeatability have been proved, the next challenge is ramping the process to high speed so that unit cost is minimized and UPH levels are maximized. Screen printing technology not only enables material control, its process speed is unmatched. Even when end-of-line mass measurement techniques have been incorporated to verify proper material volume, single machine cycle times of less than 7 sec. per unit have been achieved.

I would be remiss if I didn't mention that alternative methods have been investigated for depositing material onto fuel cell substrates, but they have not proved to be as robust or cost-effective as screen printing. A spray deposition technique known as jetting is somewhat successful in putting down a controlled volume of material, but the large amount of material wasted from overspray and atomization dramatically increases the cost of production. The other alternative is vapor-phase deposition, but its ability to effectively deposit the ink in a specific pattern is quite limited. Therefore, it would appear that screen printing is the most cost-effective and controllable method for high-volume, cost-effective production.

How long will widespread adoption of fuel cell technologies take? The jury is still out. But now that a viable, high-speed, low-cost manufacturing solution has been developed, it's probably sooner than we think. Some firms we have worked with are quoting potential annual production volumes per factory numbering in the billions, which is why per unit cost and speed are so important. I can certainly see fuel cell production volumes and speed requirements going the way of the low-cost cellphone market, which, of course, was only made viable through highly automated and fast manufacturing processes. Stay tuned. ■

Clive Ashmore is global applied process engineering manager at DEK (dek.com); cashmore@dek.com. His column appears bimonthly.