EE Times

How Battery Innovators Can Overcome the Voodoo of Scale

By Earl Wiggins 07.19.2023 0

Battery companies are getting a lot of attention, with multi-billion–dollar investments in new production facilities and technology that can power everything from electric vehicles to smart cities. Many of these breakthroughs exist only on paper or in a few prototype models that appear to work only in the artificial reality of a laboratory. The question is whether these innovations can successfully move from prototype to market scale.

The voodoo of scale can undermine the best invention. A prototype that has been tested an endless number of times in numerous applications and conditions fails completely, and for no apparent reason, when you try to build it.

Intel offers a lesson: In the mid-1970s, it had the best memory chip designs and customer samples in the business. But when fabricated in volume, Intel's chips suffered such a high-failure–yield rate that the company couldn't make a profit on them. The CEO, Andrew Grove, turned to Craig Barrett, a Stanford professor, for help.

Barrett went back to the basics. Using a separate fabrication lab, he and Intel employees duplicated every step of the fabrication process. When yield rose even by a point, Barrett froze the process in place and made a systematic change. If yield went up, he made the change a permanent part of the fab process.

He achieved the highest yield rate in the semiconductor industry—and Intel succeeded.

Getting from concept to market volume

Scalability—the ability to advance in the volume of production without sacrificing the performance or quality of each individual device—separates the winners from the losers in this industry, which is growing at a breakneck pace.

Starting with these four key areas gives you the best potential for scalability:

Proof of concept. In this phase, you are taking an idea and the schematics for that design and determining if it can be built. At this point, you are not sure whether it will work or fit into your chosen form factor. It is mostly to test performance and determine whether your design will do what you say it's supposed to do.

Prototype creation. Finding the right battery form factor is next. As batteries come in limited shapes and sizes, your choices are limited—and your decision is typically dictated first by practicality (what your design will fit) and then by the needs of your potential (or target) customer. When both of these factors match, you've found your sweet spot.

Pilot production. Answer these questions: Can you fabricate your proposed battery cell in its selected configuration and make it work? Can you produce this battery with high-enough reliability to make it profitable? Will your battery cell be a viable improvement over the competition? Can you manufacture this battery in sufficient volume to meet potential demand?If the answer to any one of these questions is no, start over.
Pilot production is the shake-out run using a real production line, but much slower and of a smaller scale. A typical speed is a few meters per minute using a continuous sheet of foil. That may seem fast, but at production scale, the process will be orders of magnitude greater.

And a little-known factor in the prototyping/pilot process is the company's secret sauce. It can be a slurry made of the company's recipe (typically in powder form) of active ingredients or magic particles that create higher densities, mixed with water or a solvent, in a proprietary ratio. Or it could be the electrode manufacturing process, in which the powder or slurry is squeezed out to make a film or put a coating on a roll of foil.

The secret sauce could be on either the anode electrode, the cathode electrode or both. When scaling battery-cell manufacturing, these two areas represent many chances for errors to be introduced into the process that impact yields, performance and reliability. The variables of mixing and coating need to be controlled and understood during the pilot process to identify the amount of variation allowed to obtain an extremely consistent and reliable result with each mix and coating run.

Once the right control of the variables is achieved, throughput needs to increase. Mixing can be done using larger batches (if you use a batch process) or by moving to a continuous process. In the coating area, you can increase throughput by using a wider foil or moving the foil at a faster speed. Think of this as going from playing slow-pitch softball to trying to hit a 100-mph fastball.

Next is the cell-assembly process. The battery-cell industry typically produces cylindrical, prismatic or pouch cells. Each type has advantages and disadvantages in terms of performance and reliability. There are also different challenges with scale to consider when deciding on a form factor.

Production scale. Now, you need millions of dollars of new equipment, an army of added employees, a reliable collection of suppliers and ready customers. Scale requires you to increase the width of the foil rolls from 200–300 mm up to 500–1,500 mm while moving through the line at 50–100 meters per minute. Gigawatt factories can produce a part in less than five seconds.

Thinking big from the start

If you haven't prepared for a serious jump in scale, starting way back to the first steps in the laboratory, you will have a very difficult time achieving a marketable production scale and surviving in the business.

From the beginning, investors should be asking similar questions: Where is the battery company within the scaling process? How has it prepared for achieving commercial scale?

If you are a potential customer, you will need to ask the same questions before you design-in a particular battery for your future products.

No matter who you are, don't believe all the hype: The battery revolution will not arrive tomorrow—and it likely won't be delivered by the companies you think.

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