Long-Life, Self-Recharging BetaBattery™

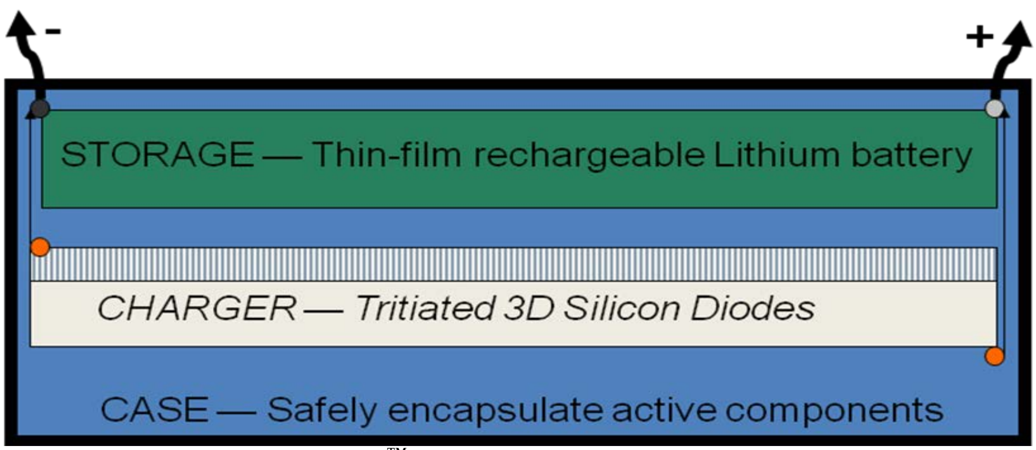
Executive Summary

The BetaBattery™ is being developed to meet the unserved defense anti-tamper and underserved medical implant long-life (20+ years) battery markets. The present size of these markets is $200-$300 million with growth trends suggesting future markets in excess of $1 billion.

The BetaBattery™

The BetaBattery is a long-life, self-recharging battery with 4 primary components:

1. Charger: Tritiated 3D silicon diodes
2. Storage: Thin-film rechargeable Lithium battery
3. Charging Control Board: Microelectronic circuitry that matches the Charger to the rechargeable battery and maintains fully-charged status
4. Case: NRC-approved hermetically-sealed case for secure containment.



Principal BetaBattery™ components – Charger, Storage and Case.
(The charge control circuitry is not shown.)

The heart of the unit is the Charger. It generates electricity very much like a solar cell, but the energy source is not the sun, but Tritium the radioactive isotope of hydrogen ($T_{½}$ = 12.3 years). Electrons emitted into the *p-n* conversion junction when a tritium nucleus decays create electron-hole pairs just like solar photons. The bulk of the development work being done to commercialize BetaBatteries is to maximize the amount of electric power the Charger produces. The major technical challenge is improving the 3D diode performance of the Charger assembly.

BetaBatt is purchasing thin-film Lithium rechargeable batteries from a leading commercial supplier. Prototype charge control boards have been procured, but highly efficient electronics must be implemented for the BetaBattery application. The hermetic case has been designed in-house using best semiconductor packaging practices and is being evaluated for NRC compliance.

Progress to Date

The 3D diodes function very much like solar cells and are manufactured using the same processes as silicon (Si) solar cells, with the additional complexity of the 3D geometry. A nominal Si solar cell in bright sunlight has a conversion efficiency of about 15%. A properly constructed 3D Si diode illuminated by beta decay electrons of Tritium (similar to dim light) should have a conversion efficiency of about 10%. The initial 3D diodes built with NSF SBIR funds had about 1% conversion efficiency. A pre-commercialization award from the State of Texas Emerging Technology Fund allowed 3D diode fabrication at a fabrication facility with solar semiconductor expertise. Unfortunately the electric power performance of the resulting 3D diodes was about 10 times less than the earlier devices and about 250 times less than a good solar cell under the same illumination conditions. Even so, pre-prototype tritiated devices produced 20 times the current of competitor prototypes.

Last year BetaBatt launched a mathematical simulation effort at the University of Texas at Arlington, not only to model the performance of the poorly performing devices, but also to determine the process and materials changes necessary to produce 3D diodes that would perform as a good solar cell, essentially100 times better than prior devices. That work has been successful. The processes and materials have been identified to fabricate new build high performance 3D diodes.

The second extremely significant accomplishment is a method to preassemble the 3D diodes into the Charger stack before infiltration with the tritiated polymer energy source. The original method was determined to be totally unsuited for commercial manufacturing. By redesigning the 3D layout of the diodes, the diodes can be stacked and sealed prior to infiltration thus greatly improving speed of assembly, vastly reducing radiation exposure to the workers, and improving the overall integrity of the Charger.

First Products

The current prototypes are planned to meet product specifications of the Department of Defense anti-tamper program: specifically 25 microWatts (μW) at 3 to 5 volts for 20+ years. It is estimated that the test and evaluation process will last 1 to 2 years. When this Integration and Commercialization Phase concludes, BetaBatt will be able to produce 100 units per month during the testing period. During this time BetaBatt expects funded development work for additional products with different power requirements and form factors. The key is the successful development of high performance 3D diodes as described above.

Conclusion

There is a market for the long-life battery. BetaBatt has a proprietary competitive advantage. Product improvements to reach the necessary performance levels have been identified. BetaBatt is poised to move forward and take this Integration and Commercialization Phase to a successful conclusion by building BetaBatteries™ that have unique and world class performance.