Evercell™

FaceCompanies.com

Thermal Energy Harvesting Power Cells Replace Batteries in IoT Sensors/Devices

Patented and Patents Pending

May 20, 2019

Evercell™ Overview

- How does Evercell™ work?
- How is Evercell™ fabricated?
- How can Evercell™ be integrated into products?
  – How can it be monetized?

Passive Structure

- Evercell™ harvests thermal energy in environments with no perceptible thermal differential.
- Uses a passive four-layer structure.
- The proximity (<200nm) of the layers promotes quantum tunneling of electrons from an electrode with a low work function surface to an opposing electrode with a comparatively higher work function surface.

Work Function

- Work function is the energy required, usually specified in electron volts (eV), for an electron to leave a surface of a material.
- In solid-state physics, the work function is the minimum thermodynamic work (i.e. energy) needed to remove an electron from a solid to a final electron position remote from the surface on the atomic scale.
- The work function is not a characteristic of a bulk material, but rather a property of the surface of the material.

Evercell™ Energy Harvesting (EH) Element Design

210 - low work function electrode (< 1.0eV)

220 - surface treatment reducing work function

230 - dielectric layer

240 - high work function electrode (> 2.0eV)

A ↑ - direction of current flow

Evercell™ Power Cell Design

- Most Evercell™ power cells will consist of a stack of electrically interconnected Evercell™ EH elements.
- A 10-cm^2 EH element would produce about 190nW of power.
- Power cells comprising stacks of 50 to 100 Evercell™ EH elements will be available to power typical sensor applications.

Fabricating Equipment

- It is anticipated that Evercell™ will be produced using conventional semiconductor fabrication equipment such as:
  - Chemical Vapor Deposition (CVD)/thermal or sputtering system
  - Reactive Ion Etching (RIE) system
  - Atomic Layer Deposition (ALD) system
  - Plasma Deposition system

Fabrication Steps (1)

- A 10-µm thick insulating layer **810** is provided (FIG 8A)
- A multiple Ångstroms thick conduction layer **820** is deposited (FIG 8B)
- Conduction Layer **820** is surface conditioned (**830**) or otherwise modified to reduce its work function (< 1.0eV) (FIG 8C)

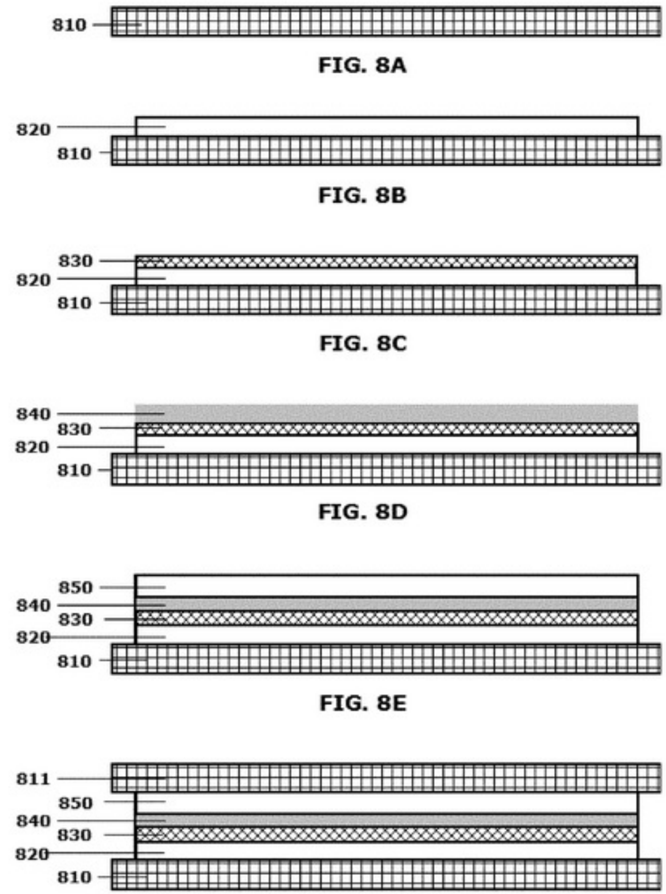
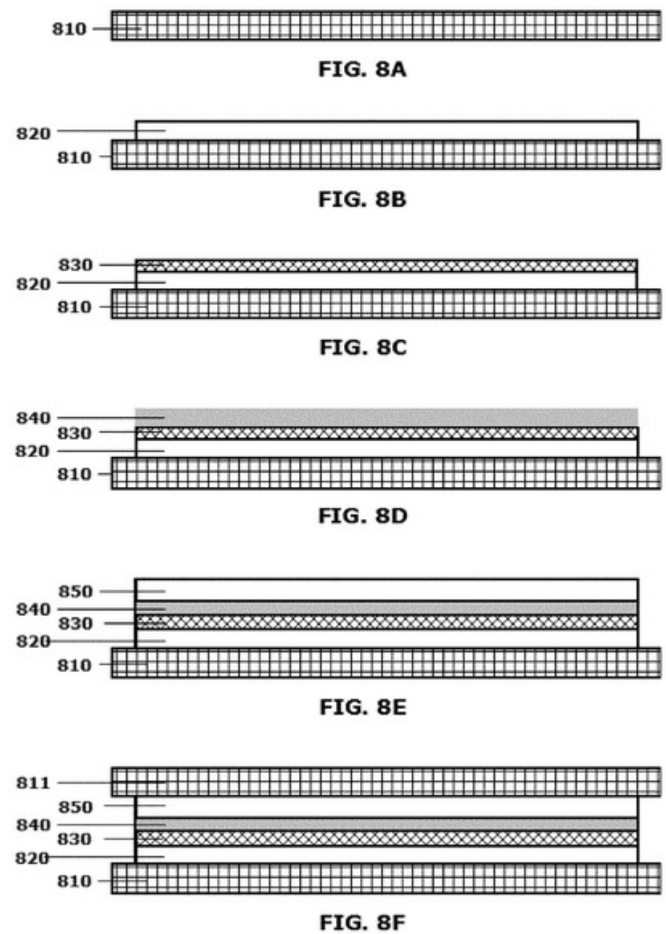


FIG. 8F

Fabrication Steps (2)

- A dielectric layer < 200nm thick (**840**) is deposited (FIG 8D)
- A high work function electrode (> 2.0eV) (**850**) is deposited (FIG 8E)
- A second 10-µm thick insulating layer **811** is provided (FIG 8F)



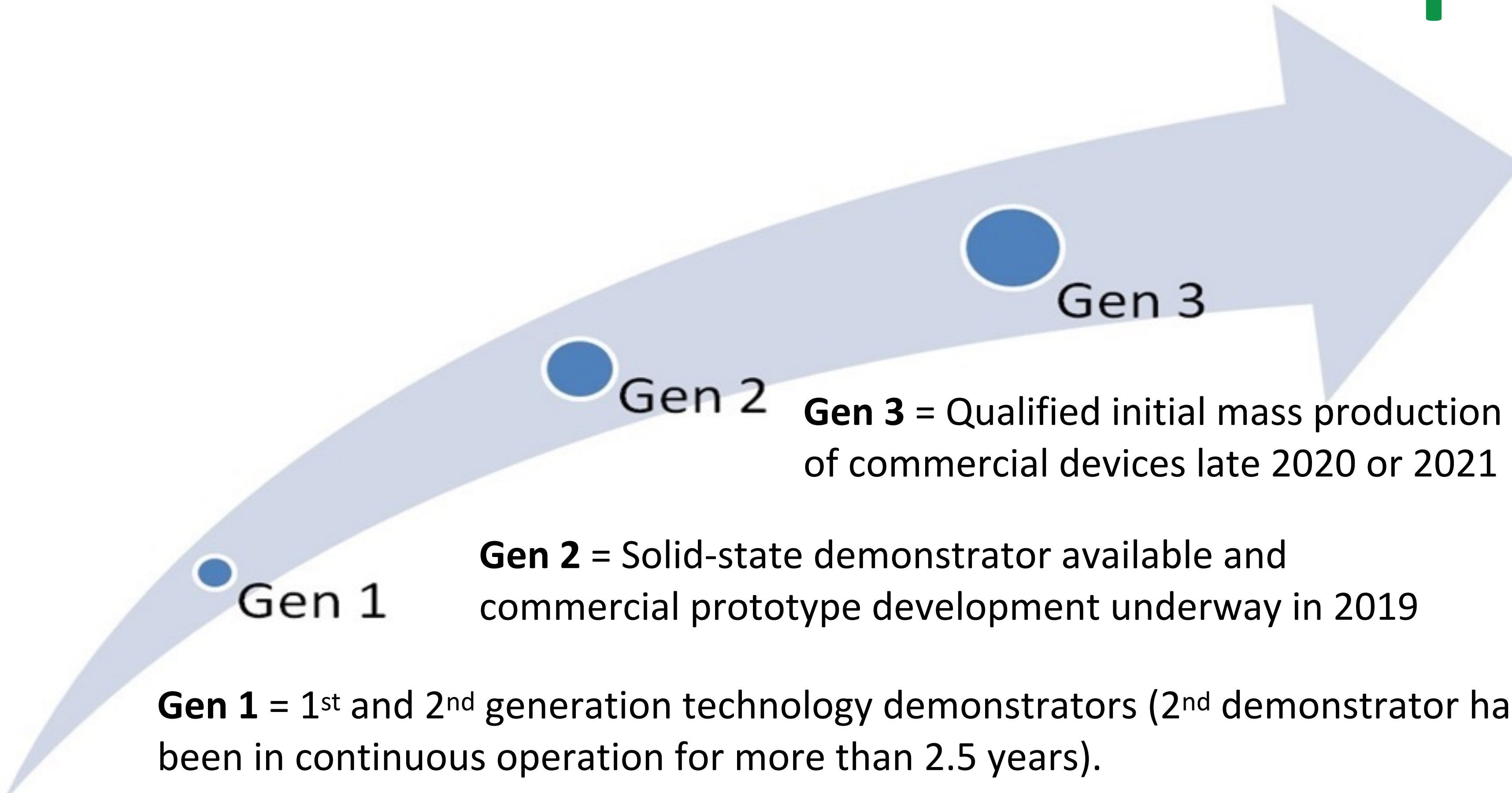
1.2V Evercell™ Power Cell

- 5-µW device (with a stack of 50 EH elements):
  - 34mm x 34mm x 1mm, 4.2µA continuous current
- 960-nW device:
  - 50mm x 75mm x 0.1mm, 800nA continuous current
- 480-nW device:
  - 30mm x 30mm x 0.2mm, 400nA continuous current

Monetizing Evercell™

- Compatible with heterogeneous integration (SiP and PCB).
- Enables the design of self-powered integrated circuits (e.g. a self-powered BLE radio that produces excess energy for sensors and other system components).
- Supported applications will include:
  - Smart watches
  - Wireless IoT sensor nodes
  - Wireless medical sensors
  - Embedded and Inhospitable Environment sensors

Evercell™ Product Roadmap



Gen 3 = Qualified initial mass production of commercial devices late 2020 or 2021

Gen 2 = Solid-state demonstrator available and commercial prototype development underway in 2019

Gen 1 = 1st and 2nd generation technology demonstrators (2nd demonstrator has been in continuous operation for more than 2.5 years).

Evercell™ Summary

- Continuous output without a perceptible temperature differential (in essentially any environment above absolute zero).
- Passive solid state structure.
- Scalable output and can be made in various form factors
- No toxic materials.
- Low-cost (when mass-production is established).
- Leverages existing semiconductor manufacturing processes.

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