Widetronix: High Power Density Betavoltaic Nuclear Batteries

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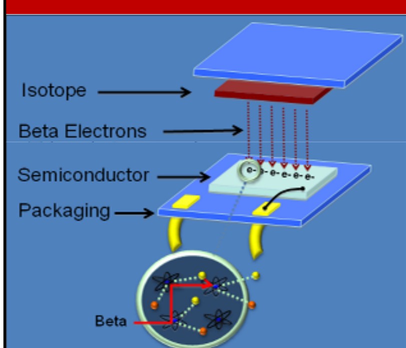
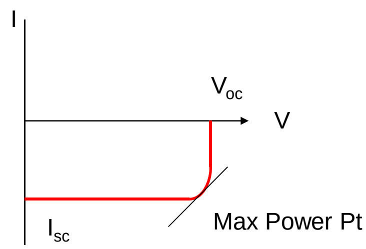
Stages of Widetronix's Development

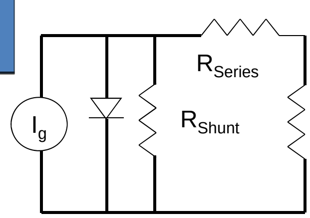
- Start Up: "The Beginnings"
- First efforts: Or a deer in the headlights
- A clear direction: Or a good story for the elevator
- A deeping understanding: Or the real value proposition
- Widetronix today:

A brief primer on betavoltaics

Betavoltaic Device







Equivalent circuit

$$I = I_{sat}(e^{\frac{qV}{kT}} - 1)$$

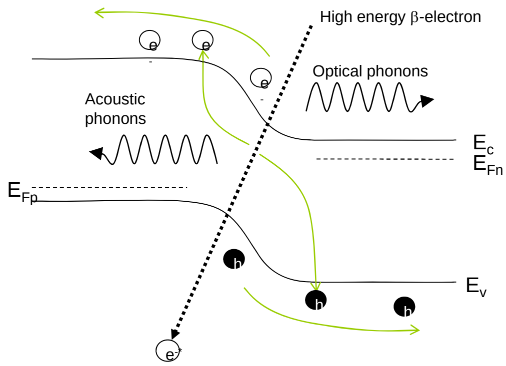
$$I_{sat} = \frac{qD_p p_{no}}{L_p} + \frac{qD_n n_{po}}{L_n}$$

$$V_{oc} = \frac{kT}{q} \ln\left(\frac{I_{sc}}{I_{sat}}\right)$$

$$P_{Max} = V_{oc} I_{sc}$$

The solar cell equations follow directly from PN junction theory. For beta-voltaics series resistance is not a problem. But a high shunt resistance must be maintained.

Generation of Short Circuit Current



Loss Mechanisms

- Surface Backscattering of electrons
- Production of Secondary electrons (<50eV)
- Emission or Absorption of Optical or Acoustic Phonons
- Scattering by Surface Plasmons (15.6eV in 6H SiC)
- Production of X-Rays

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Measurement of the mean electron-hole pair ionization energy in 4*H* SiC

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The mean ionization energy specifies how much energy is required to make an electron hole pair. We measured this parameter for SiC and determine that it had a value of 5.05eV. If the bandgap of SiC ~3.0eV then ~2.0eV of energy is lost as heat.

Planar Beta-voltaic Cell Powered by Isotope Foil

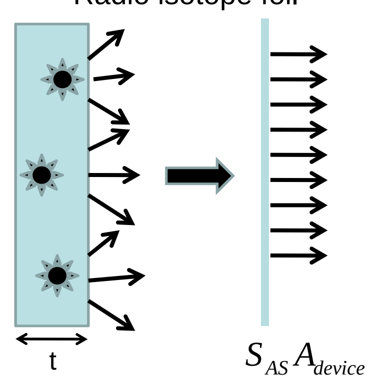
We can express the power from a planar junction cell as

$$P_{\max} = FF \frac{kT}{q} \ln\left(\frac{I_{sc}}{I_{sat}}\right) I_{sc}$$

$$I_{sc} = q \frac{Bq\langle E_{isotope}\rangle}{\langle E_{ionisation}\rangle} S_{AS} A_{device}$$

$$P_{Max} = C_{conversion} S_{AS} A_{device}$$

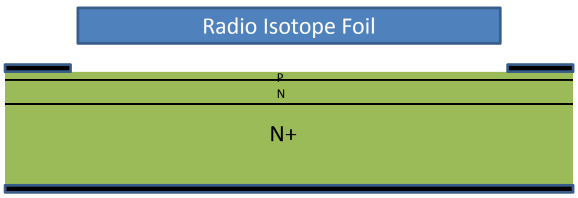
Radio isotope foil



S_{AS} is the apparent specific activity in units of Ci/cm^2 This the equivalent number of Curies that would occur if a infinite foil of thickness t was shrunk down to a plane. This neglects any shift in the mean energy of the isotope. S_{AS} is measured using a Faraday cup and the factor of 2 is taken into account

Maximum Power/Volume Utilization: Planar Structure

	E_{max} (keV)	E_{mean} (keV)	S_{AS} (Ci/cm^{-2})	R Mean (um)	R Max (um)	Pmax (uW/cm^2)	Vol Util (%)
Ni-63	67	17	.0015	1.83	20.2	.045	6.2
Tritium	18.6	5.6	.017	0.26	2.1	.19	.9



$$Vol_{util} = \frac{2t_{self\,absorb} + 2R_{mean}}{\left(t_{cell} + t_{isotope} + 2R_{mean}\right)}$$

$$t_{cell} = 50u \quad t_{isotope} = 25u$$

Volume utilization calculates the ratio of the useful area of the battery (either emitting or absorbing radiation) to the total volume. The total volume is based on the minimum thickness to which a substrate can be polished (50 microns per vendor)