Diode Energy Array Converter (DEAC) Solid State Electricity Generation Project

Thermal, Environmental and Non-Thermal Energy Harvesting in One Compact Device

Version 8.0

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Project Director

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Summary

The Diode Energy Array Converter (DEAC) Project will design, develop, produce and test a number of sample IC array’s to prove the viability of using massive arrays of zero-bias, backward tunnel Schottky diodes to harvest minute levels of Johnson noise and other RF and thermal energy from the atmosphere. Although relatively small, this power level is sufficient for powering many low power devices like smart phones, MP3 players, sensors, flashlights, and many other electronic devices. Use of the resultant high density IC’s would obviate the need for batteries or recharging of cell phones and other low power devices, dramatically expanding the growth of communications and cell phone use across the planet, particularly in third world countries. It would also allow us to replace the kerosene lantern used across the planet for illumination and student reading, breathing in the fumes and carbon emissions.

This effort has been under exploration at IRI since the discovery in 2003 that semiconductor junctions exhibit measurable Johnson noise at any temperature, including microdegrees above absolute zero. This discovery has been explored by the project director and other scientists, for the purpose of developing a new, low cost solid state renewable energy source, and confirmed by independent lab testing. Though the evidence of this phenomenon has been in the literature for years, only a twenty-year-old patent by Charles Brown, US #3,890,161, teaches the basic technique for creating a suitable array of diodes for harvesting this energy. These massive arrays of diodes effectively rectify this noise to create a sustaining, self powered solid-state electricity source worthy of 21st century energy demands. (Note: “rectification” in electrical terms is the process of converting AC electrical oscillations, including random noise and other oscillations, into usable DC electricity.)

Selection of Certain Diodes for Energy Conversion

In response to the inquiry from Chief Scientist Dennis Bushnell of NASA-Langley who recently asked Tom Valone about the extraction of energy from the quantum vacuum, after becoming aware of his book, Zero Point Energy: The Fuel of the Future, He replied that the main discovery that he made is that there exists a class of diodes (rectifiers) that operate at “zero-bias” (no voltage applied to make them work) and operate up into microwave frequencies. These Schottky type diodes are suitable for generating minute levels of electrical current from thermal fluctuations, environmental electromagnetic field (EMF) pollution, and from the ‘zero point energy’ quantum vacuum because of natural nonthermal electrical fluctuations (Johnson noise).

Peer-reviewed journal articles already document electron tunneling at zero voltage ("zero bias"). Several microwave diodes also exhibit this feature. Looking in the noise level (1/f noise or Johnson noise) is where thermal and non-thermal energy manifests. As to the nonthermal fluctuations, Practical Conversion of Zero Point Energy from the Quantum Vacuum for the Performance of Useful Work is a useful reference. ¹ Nature has also been helpful since

Johnson noise in the diodes is also generated at the junction itself and therefore, requires no minimum signal to initiate the conduction in one direction.

**Relevant Patent Search**

The following US patents are the most significant in conversion of thermal and non-thermal (zero point quantum vacuum energy or ZPE): "Rectifying Thermal Electric Noise" by Charles Brown #3,890,161, whose integrated micron-sized diode array is seen below, and #4,704,622 by Capasso, which actually acknowledges ZPE for its functional contribution.\(^2\) Capasso is an IBM engineer and indicates that his tunneling device only works if ZPE is present, much like what Planck discovered a century ago and Koch detected decades ago in the lab (Koch, 1982). I tend to think that metal-metal nanodiodes probably will be a popular brand for ZPE usage with millipore sheet assembly, as Brown suggests. I also cite the work of Yasamoto, et al. (2004, Science, 304:1944) covering peptide molecular photodiodes just 1 nm across -- another example of a molecular tool for studying this zero point energy that shows up on the molecular level.

Dr. Peter Hagelstein, who worked with Eneco, Inc. was thinking along the same lines when in 2002 he patented his "Thermal Diode for Energy Conversion" (US Patent #6,396,191), which uses a thermopile bank of thermionic diodes. These are slightly different, more like thermocouples, than the diodes that is presented in this proposal. However, Hagelstein's diodes are so efficient that he predicts that, with only a 10°C temperature difference, a water pool of six meters on a side could supply the electricity for a house. He also suggests their use as "efficiency boosters" for augmenting the performance of electric or hybrid cars.

Other diodes which exhibit the ability to rectify EMF energy include the class of "backward diodes" which operate with zero bias (no external power supply input). (See US patent #6,635,907 "Type II Interband Heterostructure Backward Diodes" and also US patent #6,870,417 "Circuit for Loss-Less Diode Equivalent") These have been used in microwave detection for decades but have never been tested for thermal or nonthermal fluctuation conversion depending on their operating frequency range. There is every reason to presume they include such ZPE radiation conversion in their everyday operation but it is unnoticed with other EMF energy being so much larger in amplitude. US Patent 6,635,907 from HRL Laboratories describes a diode with a very desirable, "highly nonlinear portion of the I-V curve near zero bias." These diodes produce a significant current of electrons when microwaves in the gigahertz range are present. Another example is US Patent #5,930,133 from Toshiba entitled, "Rectifying device for achieving a high power efficiency." They use a ‘tunnel diode’ in the backward mode so that "the turn-on voltage is zero." Could there be a better device for small voltage ZPE fluctuations that don't like to jump big barriers?

**Custom Made Zero Bias Diodes**

In 1994, Smoliner reported, for the first time, resonant tunneling while applying no voltage at all to the one-dimensional quantum wells that his team had created. They used “anharmonic oscillation” to

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\(^2\) Note: [www.google.com/patents](http://www.google.com/patents) is a good source of printable patents in PDF format.
substitute for zero point energy, which they ignored “for simplicity” though it was powering the tunneling of their electrons in each well. The figure below shows the remarkable German achievement, where the electrons prefer a zero voltage bias for the best results.

A completely passive, unamplified zero bias diode converter/detector for millimeter (GHz) waves was developed by HRL Labs in 2006 under a DARPA contract, utilizing an Sb-based "backward tunnel diode" (BTB). It is reported to be a "true zero-bias diode" that does not have significant 1/f noise when it is unamplified. It was developed for a "field radiometer" to "collect thermally radiated power" (in other words, 'night vision'). The diode array mounting allows a feed from horn antenna, which functions as a passive concentrating amplifier. The important clue is the "noise equivalent power" (NEP) of 1.1 pW per root hertz (picowatts are a trillionth of a watt) and the "noise equivalent temperature difference" of 10K, which indicate a sensitivity to Johnson noise, the source of which is known to be ZPE. Perhaps HRL Labs will consider adapting the invention for passive thermal and nonthermal zero-point energy generation (Lynch, et al., 2006).

Another invention developed in 2005 by the University of California Santa Barbara is the "semimetal-semiconductor rectifier" for similar applications, to rival the metal-semiconductor (Schottky) diodes that are more commonly known for microwave detection. These zero bias diodes can operate at room temperature and have a NEP of about 0.1 pW but a high "RF-to-DC current responsivity" of about 8 A/W (amperes per watt). Most importantly, the inventors claim that the new diodes are about 20 dB more sensitive than the best available zero-bias diodes from Hewlett-Packard (Young et al., 2005).

There also have been other inventions such as "single electron transistors" that also have "the highest signal to noise ratio" near zero bias. Furthermore, "ultrasensitive" devices that convert radio frequencies have been invented that operate at outer space temperatures (3 degrees above zero point: 3K). These devices are tiny nanotech devices so it is possible that lots of them could be assembled in arrays to produce ZPE electricity and thermal fluctuation electricity with significant power density (Brenning et al., 2006).

Other devices which also will provide the fuelless electrical energy for cars, planes and homes by simply using zinc oxide or titanium oxide films that can convert ambient heat into electricity, as used in photovoltaic panels. A few reports indicate that these work reliably for years. Such solid-state diode converters will also grab the thermal fluctuations and nonthermal ZPE in the process and therefore can work in outer space, even without solar exposure, for spaceships and extraterrestrial settlements during dust storms and overnight. More information on ZPE and alternate energy
Recent developments in nanotechnology assure us that the contemplated diode array can be significantly shrunk in size with no loss of power density, as compared to the Brown patent estimate for example (Charles Brown #3,890,161) from thirty years ago. Brown suggests that metal-metal diodes probably will be a popular brand for ZPE usage with millipore sheet assembly. While Brown patented his invention back in 1975, his idea has been revived and rejuvenated by Kuriyama’s “Method for Manufacturing a Semiconductor Device” US Patent #7,183,127 which cites Brown’s patent and others with similar cylindrically shaped pores for p-n junction design. It is encouraging to note that Kuriyama’s preferred range of diameter for each cylindrical diode is not smaller than 1 nanometer (nm) and not larger than 10 nm, an order of magnitude smaller than Brown.

In addition, several references are cited for nano-hole and nano-wire construction techniques, especially with regard to p-n or p-i-n junctions. A typical example of aluminum-silicon nanostructures has achieved an average diameter of 3 nm per cylinder with a 7 nm spacing between them, with a length of 200 nm per cylinder. Kuriyama also notes that these dimensions also hold if germanium is substituted for silicon. He also includes the important option of an electrode plate on the top and bottom of the diode array, or an electro-conductive substrate for the bottom common conductor. The smallest diameter that Kuriyama cites as a practical example has a 1 nm cylinder width with a 3 nm spacing between the diodes in 1000 nm square semiconductor dies, as seen in the Figure on this page. This creates a diode density of approximately $10^{12}$ diodes per cm$^2$ that is on the order of self-assembled quantum dot GaAs Schottky diodes grown by atomic layer molecular beam epitaxy (ALMBE) with InAs dots which have a diode density of $10^{11}$ per cm$^2$ (Hastas, 2003).

**Potential Product Development**

We are developing 3-4 initial product sizes, targeted for different power levels and applications. The first device might be a single layer VLSI chip, with approx. 10-50 M junctions to validate the concept and provide a test device for further development and selection of the best diodes, and their series length. This would likely only produce milliwatts to watt levels of power, but will be easy to produce test IC’s and measure the results in a variety of environments, including in a faraday cage, and at

varying temperature levels. The second device would be a larger die, to optimize the diode density, with a target of 200-500M diodes per IC, that might produce an output level of 50-100mw, which have significant market potential for sensors and other apps, like RFID tags, defense use, etc. Of concern also is whether the physical junction area per diode will be a factor in power generation which will be tested with micron-sized diodes versus nano-sized diodes.

The next level product would be to ‘stack’ multiple layers of the device design in order to attempt to achieve a power level that could be sufficient for powering devices like sensors, MP3 players, and some simple low power cell phones. Several of these devices might be used in tandem to power a typical ‘Smartphone’. This application would be of interest to all Cell phone manufacturers, as it would obviate the need for recharging of any cell phones using this approach. This could dramatically expand the cellphone market, particularly in third world countries. The most interesting arrangement of diode arrays might be a convenient 10 cm\(^3\) (10 cc with 2.1 cm per side), containing up to a hundred of the Phase 3 stacked arrays, which might yield a power source of over 100W!

Below is a slide that estimates Johnson noise (ZPE) nonthermal energy per frequency band and the beginning of the thermal range which has an “f” proportionality instead of 1/f dependency.

![Noise Root Power Spectra](image)

Both are estimated to be in the range of 10\(^{11}\) per cm\(^2\) diode density. Using a conservative packing density of 2 mm per layer (with 1.1 mm substrates), we can pack 5 diode array layers in 1 cc and therefore, 50 diode layers in 10 cc. This raises the diode density to 5 \times 10^{12} \text{ diodes} (5 \text{ trillion diodes}) in a 10 cc box. This is a favorable quantity which could yield a potential estimated 50 Watt DC generator from thermal and nonthermal noise combined, for the estimate of 10 pW per diode.\(^3\)

\(^3\) For comparison, see Haish, Bernard et al., US patent #7,379,286 “Quantum Vacuum Energy Extraction” which has a very similar estimate for energy output from a different, Casimir cavity device of the same size box (10 cc).
worthwhile noting that an array of a trillion molecular switches has been proposed using less than 100 zJ (100 x 10^{-21} joules) per switch based on direct experimental measurement of a single molecule (Loppacher, 2003). Loppacher et al. also note that it requires “less than a femt joule of energy” to switch a solid state transistor, which may be useful in an advanced design of a switching DEAC for AC output. (Two samples of the slideshow from the March, 2009 SPESIF meeting are below.)

**Prototype Development Stages**

**Phase 1** prototype involves hand assembling several 500 – 2000 diode arrays of an optimal zero bias diode, tested in a shielded enclosure and without the shielded enclosure for comparison, similar to the Tom Schum proof-of-principle diode array with capacitors for charge storage. SWI www.swri.org
This effort is being expanded at this time, with limited funding.

**Phase 2** prototype is the next step, to design, build, and test a **one hundred thousand to 5 million diode array** with groups like [www.MOSIS.com](http://www.MOSIS.com) for fabrication and design for voltage, current and power output. CNSE-Albany, the Center for Nanoscale Sci and Tech, and NIST (CNST NanoFab) are suitable design/test facilities that we may work with. This special large scale diode array is expected to continually produce at least the minimum amount of electricity for useful purposes.

**Phase 3** will be to manufacture a single layer of microdiodes, estimated to be in the range of **10-100 million diode density**. It is expected to confirm the expected 100 mW output (at zero degrees) from the conservative estimate of a single layer of 1 cm². The very large scale integration (VLSI) stage of 10⁹ on a chip and 10¹¹ per cm² diode density will very likely require additional funding.

**Phase 4** - This phase is designed to perform a series of field tests with any interested partners, who might have suitable applications in the sub watt range, while determining the optimum product design and configurations, and ancillary components like ultracapacitors.
Potential Options and Methods for Commercialization

A one centimeter cube (1 cc) estimate of power generation is calculated below for a 10% efficiency. It should be noted that such a volume can conveniently be flattened to fit into a cell phone with dimensions on the order of 0.5 cm x 4 cm x 0.5 cm for example. Adding an ultracapacitor to the power circuit will allow deeper current draw and a charging up of the cap overnight.

DEAC Power Cell with THz Limit

For a 10 cm³ (10 cc) box and 10% efficiency = 10 pW/diode

Nano-sized diodes = $10^{11}$ per cm²

assuming 2 mm per layer with 1 mm substrate, yields 50 diode layers = 5 trillion diodes × 10 pW = 50W

Therefore, a 1 cc cube = 5 W

This conservative estimate, assuming only a 10% efficiency for total energy conversion, still reaches the kW/m³ range of production, 24/7 from ambient thermal and non-thermal energy combined. This calculation also ignores the 1/f and the f range of noise that exceeds 10 nV and 10 fA per root hertz.

Updated for 2013

The final stage of the DEAC box development will involve a choice of

1) the Hastas self-assembled GaAs Schottky diodes or
2) the Kuriyama high density nano-size cylinder-shaped diodes.

Note - The University of Wisconsin-Madison reported in 2010 as working on utilizing noise with zinc oxide crystals immersed in water to create energy with a 20% efficiency (J. Phys. Chem. Ltrs., DOI:10.1021/jz100027t). The University of Maryland has a “rectenna” diode array project under Professor Dagenais and the University of Colorado at Boulder also has a rectenna terahertz/petahertz project under the direction of Professor Moddel. In addition, the IRI Future Energy eNews has reported on enhanced antennas that concentrate the ambient available electromagnetic energy which can be converted into electricity. The latest in the series is November 2013 edition reprinting the Duke University 37% efficient power-harvesting, rectifying metamaterial capturing “various forms of electromagnetic wave energy” to convert them into useful electricity.
Textbook Noise Estimate

*Intro. to Instrumentation and Meas.*, CRC Press, Northrop, 1997

**Voltage fluctuation noise:** nanovolt (nV) per root hertz*

**Current fluctuation noise:** femtoampere (fA) per root hertz

(Background thermal noise and light scatter may add to this estimate)

Using Koch’s measured frequency THz upper limit for current noise:

\[
(10 \text{ nV/Hz}^{1/2})(10 \text{ fA/Hz}^{1/2})(10^{12} \text{ Hz}) = 0.1 \text{ nW} = 100 \text{ pW}
\]

Assume a 10% efficiency yields 10 pW per diode for a conservative estimate

*Also see Luukamen, NIST Quantum Electrical Metrology Division, Proc. of SPIE, V. 5410, 2004 (eq. noise nV/Hz \(^{1/2}\))
# Financial Plan

**IRI-VALONE DEAC**  
**PROJECT BUDGET**

### PERSONNEL COSTS

<table>
<thead>
<tr>
<th>Position</th>
<th>Cost</th>
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<td>ENGINEER</td>
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<td>SUBCONTRACTOR CNST NANOFAB</td>
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<td>AT NIST LAB</td>
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**TOTAL OF PERSONNEL COSTS**  
$125,000

### OTPS (Other Than Personnel Services)

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**TOTAL OF OTPS COSTS**  
$225,000

**TOTAL BUDGET**  
$350,000
References


Brenning et al., J. Appl. Phys. 100, 114321, 2006


Diode Energy Array Converters
Thermal and Nonthermal

Thomas Valone, PhD, PE
Integrity Research Institute
Navy Strategic Studies Group, Nov. 12, 2009
Updated for 2013

Two Types of Energy Input for Ambient Harvesting Diode Energy Array Converters

1. Thermal Fluctuations and Ambient RF Noise
2. Nonthermal Noise Fluctuations Associated with Quantum Vacuum

1. Thermal Rectification with Tunnel Diodes

Fluctuation-induced Tunneling Conductance in Carbon Poly(3-hexylthiophene) Composites

PRL, V. 40, No. 18, 1978

Efficiency of Rectification

Marshaal (JAP 113, 2013) calculates thermal fluctuation’s white noise probability, including harvesting ambient RF radiation, using full wave rectification of rectennas a 64% efficiency (half-wave diodes are ¼ as efficient)

\[ \langle y \rangle = 1 \int y \cdot P(y) dy = \frac{2}{\sqrt{\pi}} \int y \cdot e^{-y^2} dy = \frac{\sqrt{\pi}}{2} \]

for which the rectification efficiency is

\[ \eta = \langle y \rangle^2 / \langle x \rangle = 0.6366. \]

Even higher efficiencies are predicted with more rectification stages up to 98%
Diode Energy Array Converter (DEAC) Possible Design

1) Kuriyama, Patent #7,183,127 cites Brown patent “Diode Array” #3,890,161
Kuriyama: 1 nm diode pillars with 3 nm spacing yields $10^{12}$ diodes / cm$^2$

2) COMPARES FAVORABLY TO Hastas, 2003* with GaAs Schottky diodes grown by atomic layer molecular beam epitaxy (ALMBE) yielding $10^{11}$ diodes / cm$^2$

*Hastas, J App Phys, 93, 7, 2003, p. 3990

Series and parallel arrangement of diode groups to be optimized

Noise Root Power Spectra

1/f noise graph - quantum dots

$$S(f) = \frac{(2\pi c\varepsilon_0\varepsilon_f)(2\pi c\varepsilon_0\varepsilon_f)}{2kT}$$

Josephson junction, $S_J = 10 \text{ pA/}\sqrt{\text{Hz}}$

Koch, 1982

Electron-positron production

2. Nonthermal Energy

- Zero-point energy is not conserved
- Helium stays liquid < 1°K
- ZPE density = 220 erg/cc in optical region

Quantum fluctuations of the vacuum create virtual particles (real for an instant) that produce shielding & mechanical force
Rectifying Thermal and Nonthermal Electric Noise

- Brown patent, metal-metal diodes #3,890,161
- Single electron transistors (SET) high noise at zero bias
- High resistance good for more thermal noise
- Not related to Peltier effect that needs current flow
- Self-assembled diodes
- Peptide molecular photodiodes 1 nm across
  Yasutomi et al. 2004 Science 304 1944

Nonthermal Energy in the Lab

- Josephson junction meas. at 10 GHz to 500 GHz (f_J = 2eV/h)
- Spectral density is Planck’s 2nd radiation law for ZPE (h f_J > kT)
- Dashed line is Planck’s first law for oscillators w/o ZPE (eV<kT)
- Dark energy = vacuum fluctuations directly affects electrons and other charges
- Beck analyzed Koch results
  Koch, UC Berkeley, Phys. Rev. B, 26, 1, 1982
  - Valuable for space travel -
  "Laboratory Tests on Dark Energy"

Nonthermal Spectral Density

Picojoules per second (pJ/s) = picowatts (pW)

Vacuum Fluctuations Spectral Density Equation*

\[ \rho(\omega) = \frac{h}{8\pi c^2} \left( \omega^2 - \omega_i^2 \right) \]

\[ = 300 \text{ eV/m}^3 = 10^{18} \text{ J/m}^3 = 10^{12} \text{ J/m}^3 \]

Same order of magnitude

New use gamma ray (10^8 Hz) as upper frequency limit. ZPE density = 390 MeV/m^3
and an electron is a few femtometers in size, so vacuum energy density is 60 pJ per electron

Intro. to Instrumentation and Meas., CRC Press, Northrop, 1997

Voltage fluctuation noise: nanovolt (nV) per root hertz*

Current fluctuation noise: femtoampere (fA) per root hertz

Using Koch’s measured frequency THz upper limit for current noise:

\[ (10 \text{ nV/Hz}^{1/2})(10 \text{ fA/Hz}^{1/2})(10^{12} \text{ Hz}) = 0.1 \text{ nW = 100 pW} \]

Assume a 10% efficiency yields 10 pW per diode for a conservative estimate

*Also see Luukanen, NIST Quantum Electrical Metrology Division, Proc. of SPIE, V. 5410, 2004 (eq. noise nV/Hz^{1/2})
For a 10 cm³ (10 cc) box and 10% efficiency = 10 pW/diode

Nanometer diodes = 10¹¹ per cm² assuming 2 mm per layer with 1 mm substrate, yields 50 diode layers = 5 trillion diodes x 10 pW = 50W

Therefore, a 1 cc “sugar” cube = 5 W

This conservative estimate, assuming only a 10% efficiency for total energy conversion, still reaches the kW/m³ range of production, 24/7 from ambient thermal and non-thermal energy combined. This calculation also ignores the 1/f and the f range of noise that exceeds 10 nV and 10 fA per root hertz.

**DEAC Power Cell with THz Limit**

**IRI Diode Energy Converter Research**

**Voltage Readings with 10 Meg**

23 mV across 10 MΩ = 2.3 nA

Two views of IRI Electromagnetics Research Lab

**Diode Array Example**

Courtesy of Tom Schum

**Nonthermal Energy Summary**

- Photon energy
  - Electrons: 1 eV
  - Protons: 1 MeV
  - Neutrons: 1 GeV

- ZPE energy
  - Si: 10¹⁴ eV
  - Ag: 10¹⁷ eV
  - Pt: 10¹¹ eV

- Physical cross-sectional area
  - 3 x 10⁻¹² m²
  - 3 x 10⁻¹⁸ m²
  - 3 x 10⁻²⁴ m²

- Scattering cross section
  - 10⁻⁸ m²
  - 10⁻¹⁵ m²
  - 10⁻²¹ m²

- Electromagnetic
  - Quantum coherence - Allahverdyan, Scully
  - Spatial squeezing - Hu

- Mechanical
  - Quantum Brownian nonthermal rectifiers - Goychuk

- Fluid Dynamic
  - Quantum Brownian nonthermal rectifiers - Goychuk

- Thermodynamic
  - Quantum Brownian nonthermal rectifiers - Goychuk

- Viscous resistance - Brown, Ibarra-Bracamontes, Engel

- Quantum Brownian nonthermal rectifiers - Goychuk

**Further Research Details**

- Single layer series testing to be pursued for next paper
- Two independent verifications of zero bias diode array already have surfaced
- Refrigeration effect is expected
- Hastas (GaAs Schottky diodes) measured 100 pA of forward current at zero bias
- Hundreds of kW/m³ is possible even without RF energy harvesting and 1/f and f contributions
- Noise amplification is well known, enhancement of shot noise is an example that resulted in charge accumulation

**IRI Electromagnetics Research Lab**

10 Megohm resistor in series with 10 diodes

Keithley 486 Picoammeter reads 2.27 nanoamps constant current with or w/o resistor in series

Voltage Readings with 10 Meg

23 mV across 10 MΩ = 2.3 nA

Two views of IRI Electromagnetics Research Lab

**Diode Array Example**

Courtesy of Tom Schum

**Nonthermal Energy Summary**
Thomas F. Valone, Ph.D., P. E.
9625 51st Place, College Park MD 20740
301-513-5242

EDUCATION: Ph.D. General Engineering, Kennedy-Western (Warren National) University, 2003... M.A. Physics, SUNY at Buffalo, 1984...B.S. Physics; B.S. Electrical Engineering, SUNY at Buffalo, 1974. Professional Engineer's P.E. License (NY #62475)

EXPERIENCE HIGHLIGHTS

1996-Present                U. S. PATENT & TRADEMARK OFFICE                  Alexandria, VA
Primary Examiner,
Physics, Measuring, Testing, Instrumentation Class 324, Art Unit 2858, GS-14. Electric and nonelectric properties, testing in specific environments, calibrating electric meters, sensing electricity, internal combustion engine ignition system, electromechanical switching devices, thermoelectric properties, electrostatic field sensing, fault detection, impedance/admittance testing, power measurement, motors/generators. Elected as Board member of the PTO Society, 1999. Organized Art Unit trip to NIST Conference with 16/40 time included, 1998.

1991-Present                               INTEGRITY RESEARCH INSTITUTE                 Washington DC
Professional Engineering, Energy Research Scientist, Physicist

1987-1990          INTEGRITY RESEARCH CORPORATION                                                    Buffalo, NY
Engineering Manager
Responsible for Engineering Department instrumentation projects, managed engineers and technicians, initiated several magnetic field instrument lines, trained engineering industrial student interns from SUNY at Buffalo for several years, designed 2% accuracy calibration procedures, designed specification sheets and training manual, represented company at shows, conferences.

1981-1986      ERIE COMMUNITY COLLEGE (SUNY-ACCREDITED)                                  Buffalo, NY
Instructor
(Physics, Robotics, & Electrical Tech Depts.) Courses taught included Engineering Physics, Technical Physics, Introductory Physics, AC Electricity, Electronics, Digital Logic, Microprocessors (6502), Environmental Science, as well as laboratory sessions for above courses. Designed Instrumentation & Process Control Curriculum at direction of College President. Participated in Project Outreach by teaching SUNY-contract microprocessor courses (6800) at Chevrolet Plant, Tonawanda, NY.

1976-1980          SCOTT AVIATION, DIV. OF ATO, INC.                                      Lancaster, NY
Research Scientist
(Research & Development Department) Developed gas detection linearization circuit for Series 9000 instruments, directed planning/installation of computerized test facility for catalytic sensors, performed feasibility study of non-pressurized zeolite oxygen tank for firemen, published design articles, managed acquisition and installation of computer network, numerous sensor circuit design and testing projects. Advanced to Director of R & D by fourth year.


Awards and references available upon request.
Publications by Thomas Valone, Ph.D, P.E.

BOOKS & NEWSLETTERS:
♦ Clinton Administration’s DOE: Independent Evaluation of the USDOE Comprehensive National Energy Strategy, 175 pages, 2000, supported by a grant from the Alternative Energy Institute (Author)
♦ Proceedings of the U.S. Psychotronics Association Conference, 1985, 270 pages (Editor)
♦ Future Energy, Vol. 1, Nos. 1-9, Future Energy Annual, 2004-12 (Editor)

REPORTS

Electromagnetic Fields and Life Processes
Inertial Propulsion: Concept and Experiment (Parts I & II)
Scalar Potentials, Fields, and Waves
Eric Laithwaite Report: Gyromagnetic Engineering Genius
Magnetoecephalogram (MEG) with an ELF Magnetometer
T.T. Brown's Electrogravitics Research
The Quantum Mechanics of Nuclear Magnetic Resonance
AC Electricity Formula Sheet (for Merrill Publishers)

ARTICLES

Proposed Use of Zero Bias Diode Arrays as Thermal Electric Noise Rectifiers and Non-Thermal Energy Harvesters, Proceedings of Space, Propulsion and Energy Sciences International
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James Dunn, CEO, NASA Center for Tech Development, Westborough MA, 508-870-0042
Paul Werbos, PhD, Space Solar, National Science Foundation, Arlington VA, 703-292-8339
**RECTENNA SOLAR CELLS, METAL-INSULATOR TECHNOLOGY & GEOMETRIC DIODES**

Optical Rectennas: Quantum theory of operation & experimental results  
Ultra-high-speed metal-insulator device technology  
Ultra-high speed, low capacitance, low resistance diodes for rectenna solar cells and more

**Introduction to Rectenna Solar Cells**

http://ecee.colorado.edu/~moddel/QEL/Rectenna.html

- **Comprehensive reviews**: Rectennas Solar Cells, Garret Moddel and Sachit Grover, editors, (Springer, New York, 2013). [Springer Amazon](#)
- **Brief overview**: “Solar power conversion using diodes coupled to antennas,” Garret Moddel, Zixu Zhu and Sachit Grover, 6 September 2011, SPIE Newsroom. [link](#)

**Lab Publications**


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abstract


Phiar Corporation

- Whatever happened to Phiar Corporation?

Popular Press

- New Scientist: Is night falling on classical solar cells?

- Scientific American

- IEEE Spectrum

Overview

- Metal-insulator electronics
14 September 2009

Mr. Thomas Valone, PhD, PE
Integrity Research Institute
5020 Sunnyvale Avenue, Suite 209
Beltsville, MD 20705

Dear Dr. Valone,

I am writing in follow-up to your conversations with CDR Keith Gordon and am delighted that you can meet with the CNO Fellows. We are all set for the afternoon session 1330-1630 on Tuesday, 12 November 2009 at Sims Hall in the SSG Innovation Center. We anticipate about half the time for presentation and half for discussion over a two part session. I am sure the Group will benefit from your presentation on “Zero Point Energy and the Future.”

You are part of our Fall Program which provides insights on key trends and technologies that may contribute to future warfighting concepts. In addition to Zero Point Energy, topics will focus on innovation, mind stretching, future conflicts and threats, future warfare concepts, operational art, team-building synthesis and planning, and science and technology. In your important area, you will assist the Group in shaping their work and in their concept formulation.

CDR Gordon is the coordinator for your visit; his phone number is 401-841-3355, e-mail keith.gordon@usnwc.edu. Please contact Laura Krue for assistance on administrative issues; her phone number is 401-841-2625, e-mail laura.krue@nwc.navy.mil, and fax number is 401-841-4783.

We look forward to seeing you in November!

Sincerely,

JAMES R. HOGG
Admiral, U.S. Navy (Ret)
Director

Encl:
SSG XXIX Roster
SSG XXIX

CAPT Thomas H. Bond, USN, 1600
CAPT James D. Davis, USN, 3100
CAPT Daniel H. Fillion, USN, 1310
CAPT Allan G. Galsgaard, USN, 1440
CAPT Fernandez L. Ponds, USN, 1110
CAPT Michael W. Selby, USN, 1110
Col James J. Tabak, USMC
CAPT Edward L. Takesuye, USN, 1120
CAPT Paul F. Thomas, USCG

Col Mark E. Weatherington, USAF
Dr. Valone with a handful of the full house of Navy Commanders who were briefed (below) for three hours on the applications for zero point energy converters for practical use in 2009
Tom - I have discussed the massive diode array project with several people in the IC business, including Rick Payne at TI.

He is prepared to discuss this further with some fab. engineers at TI, and has some questions for you.

I think that what we want to do can be done fairly easily, with very high junction densities, but we need to pick the proper diode devices.

Thanks,

Jim Dunn
Future Solar Systems, LLC
508-560-9421
From: Jacqueline & Thomas Valone <jtvalone@gmail.com>
Sent: Sunday, May 15, 2011 8:10 PM
To: Thomas Valone
Subject: Fwd: Aloha from Hawaii

Follow Up Flag: Follow up
Flag Status: Flagged

xxx

---------- Forwarded message ----------
From: hyson@planetpuna.com <hyson@planetpuna.com>
Date: Tue, May 10, 2011 at 7:31 PM
Subject: Aloha from Hawaii
To: IRI@starpower.net, adrainbarber1@gmail.com

Aloha Dr. Valone,

Thanks for talking with me. We are interested in helping to developing the zero bias diode.

In particular, my colleague Adrian Barber is most interested in speaking with you about all this.

Contact information:

Adrian Barber email: adrainbarber1@gmail.com
Michael Hyson email: michaelhyson@yahoo.com
(profile at: www.planetpuna.com/hyson)

Please let us know a good time to call. We are Greenwich -10

Mahalo,

Dr. Michael Hyson

--
Jacqueline Valone
Wireless Device Converts “Lost” Energy into Electric Power


Using inexpensive materials configured and tuned to capture microwave signals, researchers at Duke University’s Pratt School of Engineering have designed a power-harvesting device with efficiency similar to that of modern solar panels.

The device wirelessly converts the microwave signal to direct current voltage capable of recharging a cell phone battery or other small electronic device, according to a report appearing in the journal *Applied Physics Letters* in December 2013. (It is now available online.)

It operates on a similar principle to solar panels, which convert light energy into electrical current. But this versatile energy harvester could be tuned to harvest the signal from other energy sources, including satellite signals, sound signals or Wi-Fi signals, the researchers say.

The key to the power harvester lies in its application of metamaterials, engineered structures that can capture various forms of wave energy and tune them for useful applications.

Undergraduate engineering student Allen Hawkes, working with graduate student Alexander Katko and lead investigator Steven Cummer, professor of electrical and computer engineering, designed an electrical circuit capable of harvesting microwaves.
Duke engineering students Alexander Katko (left) and Allen Hawkes show a waveguide containing a single power-harvesting metamaterial cell, which provides enough energy to power the attached green LED.

They used a series of five fiberglass and copper energy conductors wired together on a circuit board to convert microwaves into 7.3V of electricity. By comparison, Universal Serial Bus (USB) chargers for small electronic devices provide about 5V.

“We were aiming for the highest energy efficiency we could achieve,” said Hawkes. “We had been getting energy efficiency around 6 to 10 percent, but with this design we were able to dramatically improve energy conversion to 37 percent, which is comparable to what is achieved in solar cells.”

“It’s possible to use this design for a lot of different frequencies and types of energy, including vibration and sound energy harvesting,” Katko said. “Until now, a lot of work with metamaterials has been theoretical. We are showing that with a little work, these materials can be useful for consumer applications.”

For instance, a metamaterial coating could be applied to the ceiling of a room to redirect and recover a Wi-Fi signal that would otherwise be lost, Katko said. Another application could be to improve the energy efficiency of appliances by wirelessly recovering power that is now lost during use.
“The properties of metamaterials allow for design flexibility not possible with ordinary devices like antennas,” said Katko. “When traditional antennas are close to each other in space they talk to each other and interfere with each other’s operation. The design process used to create our metamaterial array takes these effects into account, allowing the cells to work together.”

This five-cell metamaterial array developed by Duke engineers converts stray microwave energy, as from a WiFi hub, into more than 7 volts of electricity with an efficiency of 36.8 percent—comparable to a solar cell.

With additional modifications, the researchers said the power-harvesting metamaterial could potentially be built into a cell phone, allowing the phone to recharge wirelessly while not in use. This feature could, in principle, allow people living in locations without ready access to a conventional power outlet to harvest energy from a nearby cell phone tower instead.

“Our work demonstrates a simple and inexpensive approach to electromagnetic power harvesting,” said Cummer. “The beauty of the design is that the basic building blocks are self-contained and additive. One can simply assemble more blocks to increase the scavenged power.”

For example, a series of power-harvesting blocks could be assembled to capture the signal from a known set of satellites passing overhead, the researchers explained. The small
amount of energy generated from these signals might power a sensor network in a remote location such as a mountaintop or desert, allowing data collection for a long-term study that takes infrequent measurements.

The research was supported by a Multidisciplinary University Research Initiative from the Army Research Office (Contract No. W911NF-09-1-0539).

An open access copy of the original report is freely available from Duke University for those who do not have access to Applied Physics Review.