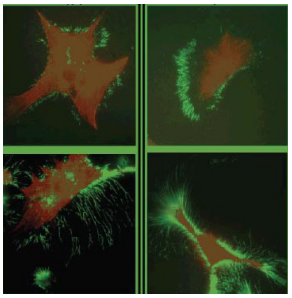


Hostos Journal of Student Research

A Publication of the Natural Sciences Department, Hostos Community College, CUNY

September 2009 Volume 1, Issue 1

In this issue:

Letter from the Editor

Dear Student,

Welcome to a new publication of the Natural Sciences Department, Hostos Journal of Students Research (HJSR).

The purpose of the Journal is to showcase achievements of students involved in research under the guidance of the Natural Sciences Department instructors. In addition, we hope that having the Journal will inspire all our students to write and publish high quality scientific manuscripts.

HJSR is a journal for the students and by the students. All articles that appear on its pages are written by students of Hostos Community College. There are two types of articles that are included in the Journal: 1) reports of original student experimental research and 2) scientific reviews done in class as an assignment or as an essay on the subject of interest. The subsequent issues of HJSR will also include your letters written in response to the articles you have read in the Journal.

The Journal will be published two times a year: a Spring issue to be published during the winter recess, and a Fall issue to be published during the summer recess.

Enjoy reading the Journal, and think about publishing your own papers on its pages.
Instructions on manuscript submission can be found on the last page of this issue.

Editorial board

Electrical Characterization of II-VI Semiconductor Using Hall Effect Measurements.

Carlos Constante[1], Mohammad Sohel[1], and Maria Tamargo[2].
1. Department of Natural Sciences Hostos Community College, Bronx, NY: 2. The City College of New York, New York, NY

This research involves the study of electrical properties of semiconductors that can be used to improve devices such as light emitting diodes (LED), lasers diodes (LDs) that emit light in the visible range and others, such as solar cells that require p-n junctions. The semiconductors of interest are II-VI compounds, such as doped ZnSe grown on GaAs substrates for solar cell structures. These materials are grown by Molecular Beam Epitaxy (MBE). We used Hall Effect measurement to experimentally determine the average resistivity, majority carrier concentration, and majority carrier mobility of doped ZnSe layers. In the Hall Effect measurements, a magnetic field is applied perpendicular to the current in a semiconductor to produce a force perpendicular to both the magnetic field and the current. This force causes charges (electron or hole) to accumulate on opposite sides of the semiconductor producing a voltage. Using mathematical expressions, we can calculate resistivity, carrier concentration and carrier mobility.

INTRODUCTION

Crystal structures are arrangement of atoms. There are three types of crystal structures:
Metals, Insulators and Semiconductors. Metals have the property of being excellent conductors because they have abundance of free electrons and can carry currents. They are composed by two energy bands: an upper band called conduction band EC which is mostly empty and a lower band called valence band Ev which is occupied by valence electrons. In addition, they have an energy gap of zero. Energy gap also called band gap EG separates the conduction band and valence band. Its magnitude's is determine the energy that electrons in the valence band need in order to be promoted into the conduction band. Insulators are poor conductor because they have no free electrons, therefore they cannot carry current and they have a huge band gap (3).
Semiconductors are similar to insulators. They have a band gap; however, this gap is not
too large. There are two types of semiconductors: intrinsic and extrinsic. An intrinsic
semiconductor is pure. They have the property that all the valence electrons of the atoms are forming valence bonds with adjacent atoms. Therefore there are no free electrons that can conduct current. In addition, the number of holes (positive charges) and electrons (negative charges) are equal. There are two types of extrinsic semiconductors: n-type and p-type (Fig.1 and Fig. 2). N-type semiconductor is characterized by the accumulation of free electron in the conduction band ***Ec*** and the P-type semiconductor for the creation of holes in the valence band ***Ev***. The measurement of the majority carrier density will determine the type of semiconductor (3). Additionally, doping is the process of adding impurities to a semiconductor which will

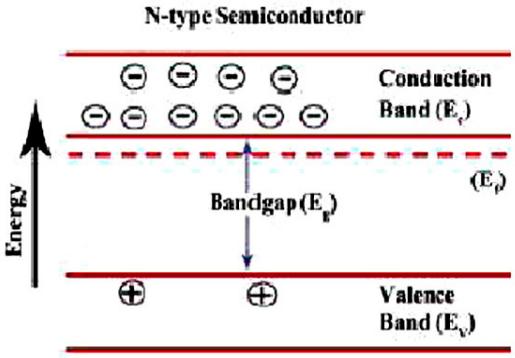


Figure 1 N-type semiconductor
N-type semiconductor is characterized by accumulation of free electron in the conduction band ***Ec***

alter its conductivity. For example, if a semiconductor atom has four valence electrons as in the case in Si (Silicon), and impurity atom has five valence electrons like As (Arsenic), this will cause an
excess of electron that can carry current; this is called an n-type semiconductor. On the other hand, if the semiconductor atom has four valence electrons and the impurity atom has only three valence electrons like Ga (Gallium) there will be missing one electron (creating a hole); this is a p-type semiconductor (2).
We use the Hall Effect measurement technique which

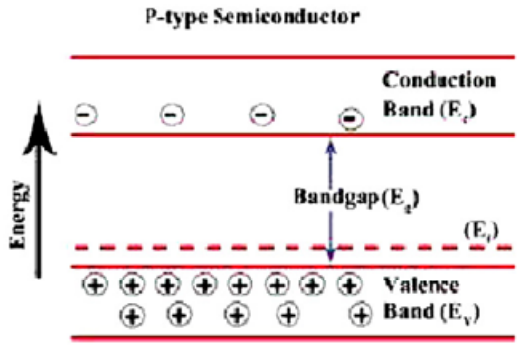


Figure 2 P-type semiconductor
P-type semiconductor for the creation of holes in the valence band ***Ev***

was introduced by E.H. Hall in 1879 to calculate resistivity, carrier concentration and carrier mobility. This effect occurs when a magnetic field is applied perpendicular to the current flow in a semiconductor; a voltage is formed perpendicular to the magnetic field and the current. This is called Hall Voltage (Fig.3 and Fig.4). In addition in

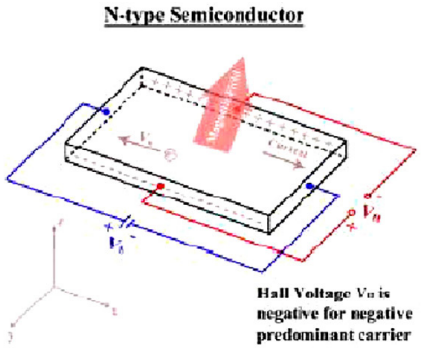


Figure 3 Hall Voltage in N-type Semiconducter

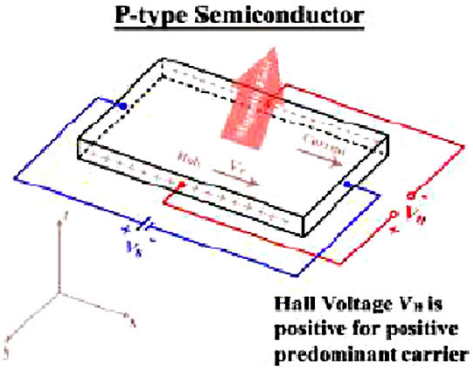


Figure 4 Hall Voltage in N-type Semiconducter

physics this force is known as the Lorentz force, which is the force on a point charge due to electromagnetic fields and it equation is :F=q (E+v*B) where F is the force, E is the electric field, B is the magnetic field, q is the electric charge of a particle, v is the instantaneous velocity of the particle. The expression qE is called the electric force, while the expression qv * B is called the magnetic force. According to some definitions, the term "Lorentz force" refers specifically to the formula for the magnetic force: Fmag=qv*B. This force F causes the particle to be deflected and a buildup of charges occur in the perpendicular direction, explaining the Hall Voltage (4).

In this paper, we report seven different measurements of samples ZnSe (Zinc Selenide)
on GaAs (Gallium Arsenide) substrate dope with Cl2 (Chlorine) cell and grown by Molecular Beam Epitaxy (MBE) technique with different thickness and Cl2 cell temperature. The MBE technique was invented in the late 1960s by J. R. Arthur and Alfred Y. Cho. Moreover the MBE is one of several techniques of depositing single crystals and is used to grow and characterize thin crystalline films of oxides and ceramics to understand in detail the chemistry that occurs on oxides and ceramic surfaces (3). The results obtained in this research will determine opt to what level we can control the conductivity of the samples.

MATERIALS AND METHODS

Using the Riber 2300P MBE system at The City College of New York (Fig. 6) we can
describe the growth sequence of a sample ZnSe_Cl

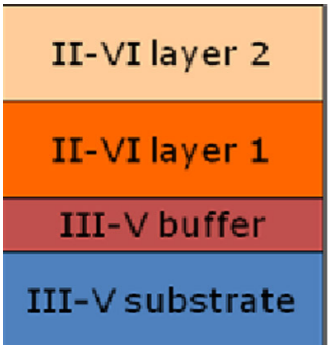
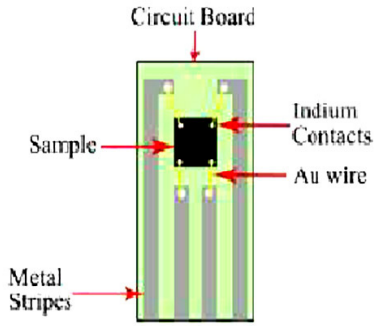


Figure 6 Riber 2300P MBE structure

as follow: we first insert substrate wafer into loading chamber, then pump to Ultra High Vacuum, transfer substrate to III-V chamber, remove oxide, and grow III-V buffer layer, transfer wafer to II-VI chamber, prepare II-VI/III-V interface, grow II-VI structure, and remove sample from growth system (Fig. 6). After the sample is grown we cut it into a square 5mm x 5mm. Then place the sample on a circuit board and secure to it with

double tape. We use Au “gold” wire and In “indium” dots to make contact between the sample and metal stripes of the circuit board (Fig. 5). Then we can



Making a semiconductor circuit for

Figure 5 Semiconductor circuit for Hall Effect measurments

divide the Hall Measurement in two steps. In the first step we use the Hall Effect System to measure eight voltages without the magnet and applying the Van der Pauw technique to determine the contact errors and the resistivity. A Hall Effect System consists of a variety of instruments such as: a digital voltmeter (measures the voltage across contacts), a current source (current source for the sample), a picoammeter (measures the current across contacts), a magnet with power supply, a switching matrix (switches the configuration of the contacts) and a cooling water unit (cool the temperature of the system) (Fig. 7).

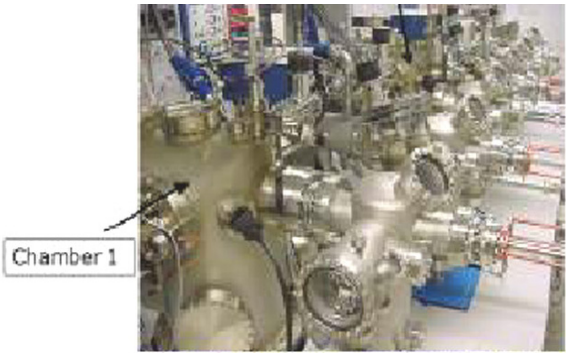


Figure 7 City College MBEGrowth Apparatus

The Van der Pauw technique consists in applying a current in one side of the sample such
as I12 and measure the voltage V1 on the other side such as V43, the process is the same for the other three sides of the sample. For accurate results we change the polarity of the current I21 and measure V5 and we do the same with the other three measurements (Fig. 8). This technique will

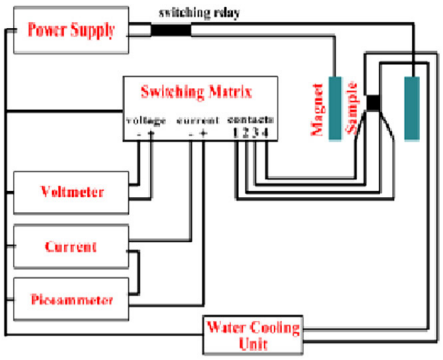


Figure 8 Hall Effect System

provide us the contact errors and the resistivity of the sample which are indispensable in the second step. In order to find the hall voltage, the carrier’s density, concentration and type we need to measure eight more voltages however this time applying a magnetic field perpendicular to the current. This process differs from the Van der Pauw technique in two aspects. First, the current is applied across the sample such as I13 and

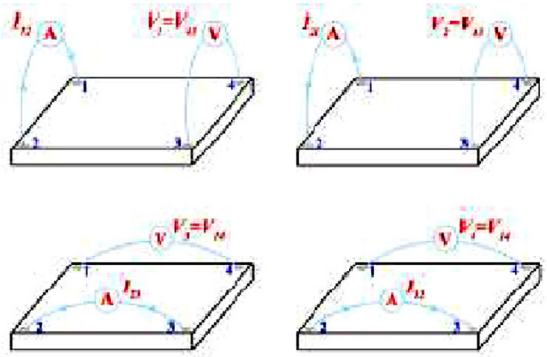


Figure 9 Magnet polarity schematics

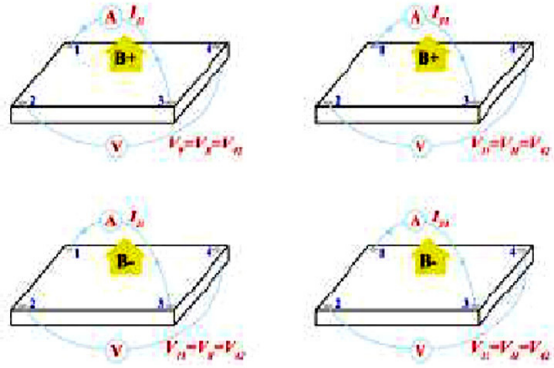


Figure 10 Magnet polarity schematics

second the voltage V9 is measure at the remaining corners V42.

Then, we switch the polarity of the magnet for accuracy purposes and we do the same process for the next six voltages measurements (Fig. 9 and Fig 10). After obtaining these 16 reading we created a worksheet (Microsoft Excel) and store the mathematical formulas to obtain the electrical characteristic of the sample. We repeat this process with the other samples and make a table which it will help us to understand and control the grown of the samples.

The main goal of the first half of the process is to calculate the contact errors and the resistivity and start by measuring eight voltages values without the magnetic field and the mathematical expressions that we use are the following: resistances that can be calculated as follow:

$$R_1=\frac{V_1}{I} \quad R_2=\frac{V_2}{I} \quad R_3=\frac{V_3}{I} \quad R_4=\frac{V_4}{I} \quad R_5=\frac{V_5}{I} \quad R_6=\frac{V_6}{I} \quad R_7=\frac{V_7}{I} \quad R_8=\frac{V_8}{I}$$

Then, we can calculate the contact errors using the following expressions:

$$E_1\%=\left|\frac{R_1-R_2}{R_1}\right|*100 \quad E_2\%=\left|\frac{R_3-R_4}{R_3}\right|*100 \quad E_3\%=\left|\frac{R_5-R_6}{R_5}\right|*100 \quad E_4\%=\left|\frac{R_7-R_8}{R_7}\right|*100$$

Now we need to calculate the average resistance of each pair of contacts as follows:

$$R_a=\frac{R_1+R_2}{2} \quad R_b=\frac{R_3+R_4}{2} \quad R_c=\frac{R_5+R_6}{2} \quad R_d=\frac{R_7+R_8}{2}$$

Based on this results the symmetry factor can be calculated as follows:

$$F=1-\left[\frac{R_b-R_a}{R_b+R_a}\right]^2*\frac{\ln 2}{2}-\left[\frac{R_b-R_a}{R_b+R_a}\right]^4*\left[\frac{(\ln 2)^2}{4}-\frac{(\ln 2)^3}{12}\right]$$

Next we calculate the sample's resistance:

$$R_s=\frac{R_a+R_b+R_c+R_d}{4} \quad R_s=\frac{R_a+R_b+R_c+R_d}{4}$$

Now we have all the parameters we need in order to calculate the resistivity:

$$\rho=\frac{\pi}{\ln 2}*1e^{-4}*F*t_s*R$$

Where were ρ is the resistivity in ohm/cm and ts is the sample thickness in Nm.

In the second half we measure another eight voltages with the presence of the magnetic field to determine carrier type, mobility and concentration. Then we calculate the average voltage for each configuration:

$$V_{1F}=\frac{V_9-V_{10}}{2} \quad V_{1R}=\frac{V_{11}-V_{12}}{2} \quad V_{2F}=\frac{V_{13}-V_{14}}{2} \quad V_{2R}=\frac{V_{15}-V_{16}}{2}$$

Then we calculate the Hall voltage for each configuration:

$$V_{H1}=\frac{V_{1F}-V_{1R}}{2} \qquad V_{H2}=\frac{V_{2F}-V_{2R}}{2}$$

Now we calculate the Hall coefficient for each configuration:

$$R_{H1}=\left[\frac{V_{H1}}{I}\right]*\left[\frac{t_s}{B}\right]*10 \qquad R_{H2}=\left[\frac{V_{H2}}{I}\right]*\left[\frac{t_s}{B}\right]*10$$

Where RH1 and RH2 are the Hall coefficients in cm^3/C and B is the magnetic flux in gauss (G). Calculate the average Hall coefficient and the error:

$$R_H=\frac{R_{H2}+R_{H1}}{2} \qquad E\%=\left|\frac{R_{H1}-R_{H2}}{R_{H1}}\right|*100$$

Determination of the carrier type: if RH is negative equal n-type or if RH is positive equal p-type.

Then we calculate the carrier concentration:

$$(1.6E^{-19}*|R_H|)^{-1}$$

At final we calculate the carrier mobility:

$$\mu_H=\frac{|R_H|}{\rho} \qquad 100$$

Where μ_H is the mobility in cm^2/V-s

RESULTS AND CONCLUSION

The results obtained show that as carrier concentration increases, mobility decreases. In addition, they show that as thickness increases, the carrier concentration decrease and therefore mobility increases. We were unable to detect the connection between applied current and other characteristics of the samples given. When we were applying a diminutive amount of current to a p-type sample, this prevents the machine from reading the values correctly. This causes the measurements to be very small and therefore erroneous, to correct this we apply a greater amount of current which give us a better reading.

ZnCl2 cell temperature was varied from 66ºC to 80ºC. The results of the carrier concentration and mobility appear reasonable. As the data indicates in the Figure 10 and Figure 11, where we create a scatter chart, and plot the free carrier concentration of Cl doped ZnSe as a function of ZnCl2 cell temperature and the mobility of Cl doped ZnSe as a function of ZnCl2 cell temperature, the carrier concentration increases and the mobility decreases with increasing ZnCl2 cell temperature. This behavior

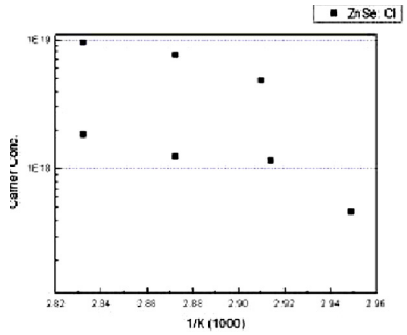


Figure 11 Free carrier concentration of Cl doped ZnSe as a function of ZnCl2 cell temperature

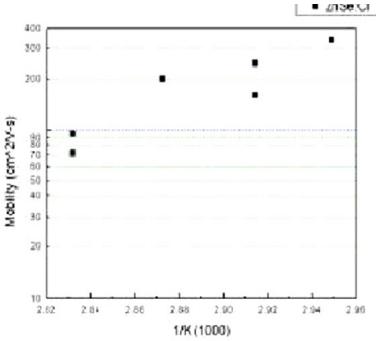


Figure 12 Mobility of Cl doped ZnSe as a function of ZnCl2 cell temperature

appears reasonable. However, samples A2624, A2625 and A2627 have higher carrier concentration than the others (Table 1). This requires further investigation.

Table 1

Summary of Measured Samples

Sample	Descrip.	Current	Ts (μm)	Conc. (cm^3)	Mob (cm2/V-s)	Temp °C
A2624	ZnSe: Cl	1.00E-03	0.58	4.9E+18	161	70
A2625	ZnSe: Cl	1.00E-03	0.52	7.6E+18	202	75
A2626	ZnSe: Cl	1.00E-04	0.71	9.7E+18	96	80
A2627	ZnSe: Cl	1.00E-04	0.95	1.16E+18	249	70
A2628	ZnSe: Cl	1.00E-04	0.95	1.78E+18	72	80
A2630	ZnSe: Cl	1.00E-04	1	1.25E+18	202	75
A2631	ZnSe: Cl	1.00E-03	1	4.70E+17	344	66

In order to obtain good results from the measurement careful operation is required.
Primary sources of errors can be the contacts quality and size and accurate thickness
determination. Using Hall Effect measurement data we can control and optimize the growth conditions for doped ZnSe samples (4). It is necessary also to have good crystalline quality of the sample for device performance, which can be assessed by x-ray and photoluminescence measurements.

ACKNOWLEDGMENTS

I would like to thank my mentor Dr. Mohammad Sohel for giving me the opportunity to
participle in the research program, for his knowledge, support and supervision. I would also like to thank the support of Dr. Maria C. Tamargo at City College of New York for allowing me to use the research facility and for her supervision. Special thanks go to Taha Abdulla, William Charles, and Qiang Zhang who provide me importance advice and knowledge of the usage of the Hall Effect System.

REFERENCES

1. W. Lin, A. Cavus, L. Zeng and M. C. Tamargo, 1998 N-type doping of lattice-matched
ZnCdSe and ZnxCdyMg1-x-ySe epilayers on InP using ZnCl2. Journal of Applied
Physics, 84:1472-1475, ()
2. National Institute of Standard and Technology. Hall Effect Measurements.
http://www.eeel.nist.gov/812/hall.html. Accessed June 30, 2008.
3. Harbison, James P and Nahory E. Robert. 1998. Lasers Harnessing the Atom's Light. New York: Scientific American. Library.
4. Cheng T. Wang. 1990. Introduction to Semiconductor Technology. John Wiley & Sons, Inc. New York.

Corresponding author: M.Sohel msohel@hostos.cuny.edu

Renewable Vortex Energy: Atmospheric and Water Vortices

Dane Christie and Yoel Rodriguez
Natural Sciences Department, Hostos Community College, Bronx, New York.

The search for a renewable energy source capable of replacing fossil fuels and coal has moved to the forefront of the U.S. government's energy plans. Renewable vortex energy could be the solution to the energy problems faced by our society. By harnessing the power of a tornado, inventor Louis Michaud has proposed the implementation of the Atmospheric Vortex Engine (AVE) which is a machine capable of generating up to 200 MW of energy. Michael Bernitsas of the University of Michigan has developed an aquatic energy harnessing system – Vortex Induced Vibrations for Aquatic Clean Energy (VIVACE) - that uses the vortices generated by water as it passes over submerged objects to generate energy. The biggest appeal of this system is that it operates over a wide range of water currents. The future success of these systems depends on how well they will fit into the ecosystem of the U.S.

INTRODUCTION

Since the beginning of time, there has been an ongoing search for a source of energy to supply the world's energy demand. Up until the industrial revolution, the main source of energy was produced by burning wood. The emergence of the industrial revolution produced an entirely new market that was driven by energy. Coal primarily fueled this market until more abundant fossil fuels moved to the forefront of energy production. Fossil fuels appealed to the energy market because of their high combustion energy and production cost. In time, the secondary effects of using energy sources that release carbon dioxide (CO_2) and other gases were seen in the harm inflicted on the global ecosystem.

The greenhouse gas effect has sparked a race against time for present and future generations. It is obvious that the world's energy demand increases every year. Greenhouse-gas producing raw materials causes severe damage to our environment and inevitably threatens our future survival. Alternate energy sources have been devised in an attempt to stop these effects.

Nuclear energy was once considered to be the savior of the world's energy demand. However, the radioactive by-products of nuclear energy prevent its use as a viable replacement for fossil fuels and coal. Solar energy is the most researched source of the renewable energy market. Solar energy is vastly available, free, and has no harmful by-products. Harvesting this energy cost effectively has proven to be a daunting task.

Wind energy sources have now moved to the forefront of supplying renewable energy to meet our energy needs. Despite being used for centuries, wind energy has only been commercialized for less than 50 years. One unintended effect resultant from using wind energy is an interruption in the regular wind current patterns around the globe. Long term effects of this wind current readjustment remains to be seen. A new fuel derived from our waste - Syngas (Synthesis gas, which is a gas mixture that comprises of carbon monoxide, carbon dioxide and hydrogen) has been invented. This process contributes to the increase of greenhouse gases in the atmosphere. In the end, it will not solve the problem of satisfying the world's energy demand without causing damage to our environment. Therefore, an efficient energy that does not damage our environment is needed to save our planet.

There are other renewable energy sources that help to satisfy the energy demand of the world (e.g. hydrogen, hydroelectric, biodiesel). These sources of energy are available but in most cases relatively expensive. In a world that revolves around cost effective means of production, it will prove impossible for some of the alternate energy sources to replace cheaper but more detrimental energy sources currently in use (fossil fuel, coal). Tidal and wave energy sources that are currently being used function best if the tidal water current speeds are relatively high. Tidal wave energy technology is limited because there are not many places in the world that support the current speeds necessary to operate these systems.

Vortices exist in nature from the movement of water around objects to gargantuan tropical storm systems and tornados. A vortex is a whirling mass of substance, especially water or air that draws everything near it toward its center (10). To date, no methods of harvesting energy from

vortices have been commercialized. If the energy produced in a tornado could be harvested, it would prove invaluable to bridging the energy supply-demand gap.

Mechanical engineer Louis Michaud has invented a machine that could do just that. The object of Dr Michaud's invention is to control one of nature's most disastrous elements, a tornado. If implemented, the Atmospheric Vortex Engine would revolutionize the world's energy market. The use of this machine to produce energy will be examined in more detail. The pros and cons of the implementation of this invention will also be discussed.

University of Michigan College of Engineering in collaboration with University of Michigan Marine Hydrodynamics laboratory directed by Michael Bernitsas have developed a machine capable of harnessing tidal and wave energy at low water current speeds (1). This invention uses the vortices generated by water as it moves across cylindrical objects to generate electricity. The immediate appeal of this invention is that it would be operational over a wide range of water sources (rivers, lakes, oceans, etc.) (8).

This research will explore the energy producing capabilities of harnessing energy from above mentioned vortices. Much information remains to be learned about renewable energy from vortices.

Atmospheric Vortex Engine

A tornado is a violently rotating column of air, pendant from a cumuliform cloud or underneath a cumuliform cloud, and often visible as a funnel cloud. The mechanism of how tornados form is not completely understood. Tornado wind speeds are still largely unknown. However, wind speeds of up to 312 mph (miles per hour) have been recorded in some tornado vortices. In order for a funnel cloud to be classified as a tornado, it must be in contact with the ground. The length of a tornado spans from the base of the troposphere (the ground) to an altitude of ten kilometers above its base (5).

Water vapor has the highest heat capacity among the greenhouse gases. When energy from the sun reaches Earth, it is absorbed and held by the water vapor in the atmosphere. Energy that is reflected by the earth into outer space is also absorbed by water vapor in the atmosphere. Water vapor absorbs heat mainly by means of infrared electromagnetic energy. As this water vapor is heated it rises and condenses releasing heat. This heat is absorbed by the surrounding air molecules by means of convection, a process of heat transport which results from the change of position of warm and cold fluid masses (3). The energy released by water vapor in the troposphere is 2,500-kJ/kg (9). As this energy is released, cooled water vapor precipitates. It sometimes returns to earth in rainfall. The phase changes of water in the atmosphere, from gas to liquid to solid and vice versa, plays an important role in the water cycle.

Tornados can be seen as one of the mechanisms the Earth uses to cool itself. The source of energy of a tornado lies in the buoyancy of the air rising in the eyewall of the vortex. An air mass becomes buoyant when its density is less than the density of the ambient air within which it resides (9). Air is a mixture of gases. Air masses with higher partial pressures of water vapor have more energy per mass (J/kg). For this reason, a rise in severe storm systems correlates with an overall rise in the concentration of water vapor in the atmosphere (3). The rate of the phase changes of water vapor in the atmosphere are amplified in a tornado system. Tornados weaken and dissipate partly because they move from areas with high levels of water vapor to areas with low levels of water vapor. Vast amounts of energy are released and lost in tornado energy systems (5).

An atmospheric vortex engine (AVE) is a device for producing energy using a controlled vortex (tornado). The vortex is produced by spinning warm air tangentially into a circular arena so that it spins about the vertical axis as it rises. The vortex would have a diameter of 30 meters and be housed in a 100-m diameter tower (11). A burst of steam would be used to start the updraft. A continuous source of warm air would be used to sustain the vortex. Steam injectors would be used to control the size of the vortex. It is hypothesized that once a vortex is started it will sustain itself using air from the atmosphere as its fuel (7). The concept of the AVE is inspired by the principles that govern a solar chimney (3). The AVE is the brainchild of engineer Louis Michaud.

A solar chimney is a solar thermal power plant wherein heated air rises in a tall chimney. The air is heated in a very large greenhouse-like structure (solar collector) at the base of the tower. The air current that drives up the chimney moves turbines as they exit the chimney. The efficiency of the solar chimney is directly proportional to the size of its base and the height of its chimney (9). The height of the chimney would be restricted by production costs and by the absolute height that a structure can be built considering the limitations of present technology available to us (12).

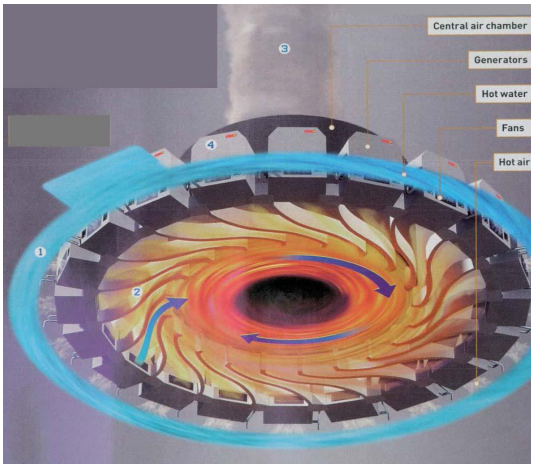


Figure 1. A virtual view of an AVE from below (11). Courtesy of Vortex Engine (http://www.vortexengine.ca).

An AVE would replace a chimney restricted by height with a vortex that reaches the upper level of the troposphere. In theory an atmospheric vortex engine would be more efficient than a solar chimney. The height of the vortex would greatly exceed that of a solar tower (3). The land space used by the AVE would also be significantly smaller than the latter because it does not require a solar collector to be functional. The construction costs of an AVE would be significantly smaller than that of a solar chimney because it does not require a large tower or a solar collector (9).

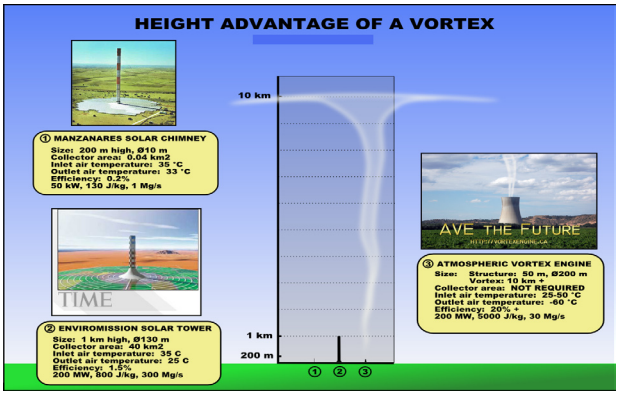


Figure 2. A comparison of the height of AVE and a solar tower.
Courtesy of Vortex Engine (http://www.vortexengine.ca).

The Convective Available Potential Energy (CAPE) is the kinetic energy that would be produced by the force of buoyancy in a frictionless flow. This is the energy that an AVE would harvest (Michaud). Turbines placed at the air inlet tunnels would be turned by air entering the system. Electricity would be produced by the turbines driving electrical generators. The power output of the AVE is dependent on the capacity of the turbines and the generators. The vortex will be controlled by steam injectors within the engine and by fans that are capable of spinning in the opposite direction to stop the airflow of the vortex (11).

Nuclear generating plants operate at an efficiency of about 33%. An AVE converting the waste heat of a power plant could increase its efficiency by 20%. A heat engine's efficiency is dependent on the temperature difference between fluid at the input of the engine and at the output of the engine after the fluid does work (Carnot efficiency). Replacing traditional cooling towers with the AVE will increase a nuclear plant's efficiency by using the plant's waste heat as the AVE's source of energy. The energy produced by the AVE would in turn be redistributed by the power plant (4).

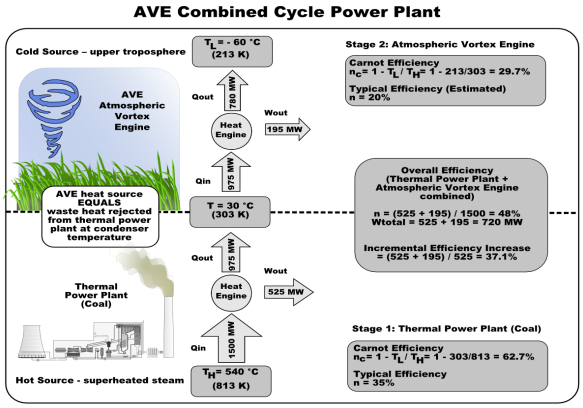


Figure 3.The effect of the AVE on the efficiency of a power plant.
Courtesy of Vortex Engine (http://www.vortexengine.ca).

Lightning is sometimes associated with tornado weather systems. Lightning in the atmosphere naturally produces ammonia (NH_3). The ammonia produced in this system would enhance the richness of the soil around the vortex. Acid rain could also be a byproduct the AVE. Nitrogen reacts with oxygen in the presence of lightning according to the following reaction: $N_2(g) + O_2(g) \rightarrow NO_x(g)$, where x denotes the number oxygen atoms in a one molecule of the compound and (g) represents the gaseous physical state. These compounds dissolve in water and are classified as acids because of their ability to donate hydrogen ions (H^+) once dissolved in water. Acid rain is not only restricted to compounds formed

from the reaction of nitrogen with oxygen. Pollutants such as sulfur dioxide (SO_2) also dissolve in water in the atmosphere to form sulfurous acid (H_2SO_3). It is unknown how an AVE would affect the nitrogen cycle. A vortex system would also redistribute pollutants found in its immediate atmosphere. The AVE is a zero greenhouse gas emissions system. The production of more energy using less raw materials (oil, radioactive materials) could possibly reverse the greenhouse effect.

Changes to the global weather system caused by an AVE are unknown. The AVE is still in its theoretical stage of progress. All of the above data are hypothesized and subject to change once operational status is achieved. The fear of a synthetic tornado escaping its base and damaging the environment is very real. Tests of small prototypes have proved to be successful. The application of such a system however, is very difficult. Granting permission to test a full scale AVE will be a daunting task. It is important to note that public opinion heavily influences the laws that govern the United States and Canada. The idea of a tornado strikes fear into the heart of all people because of its awesome destructive power. The future of the AVE is unpredictable. It may someday be seen as one of the means of meeting the energy demands of planet Earth.

Vortex Induced Vibrations for Aquatic Clean Energy

Technologies exist that are capable of harnessing energy from water currents. There are 25 concepts for capturing energy from water currents. The available technology is efficient for harnessing this energy if the speeds of the currents are relatively high: 1.15 mph or six knots. This estimate is according to the 2006 report by the Electric Power Research Institute (EPRI) North America Tidal In-stream Energy Conversion Technology Feasibility Study. The biggest new wave project is in Portugal, where Pelamis Wave Power is building the world's largest wave farm. Applying the present technology is limited to places where high water current speeds exist (8).

Vortex Induced Vibrations for Aquatic Clean Energy (VIVACE), is a new concept that is capable of harnessing energy from water currents with speeds below two knots. VIVACE energy systems could then be applicable over a wide range of water systems (1).

When water currents flow over an underwater obstacle, it creates vortices alternately above and below it. These vortices are capable of destroying bridges and offshore oil rigs. Vortices created in water currents are independent of the speed of the current. The vortices created in the water current as it moves around an object result in alternate forces that yank the object up and down (6). VIVACE systems are designed to use the effect of the movement caused by vortices to turn an electrical generator which will produce energy. The vortex shedding system used by VIVACE is similar to the mechanism used by fish to propel in the water faster than their bodies allow (13). This phenomenon also limits the ability of the VIVACE system to produce energy. An attempt to extract more energy than certain a limit causes termination of the synchronization of the oscillations of the cylinders in the system resulting in its shutting down (1). The principles that govern the operation of VIVACE system are relatively easy to comprehend.

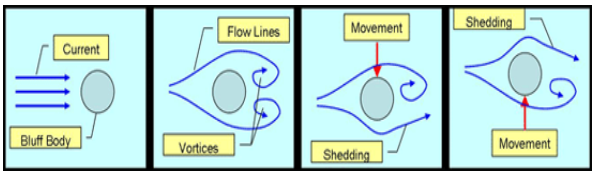


Figure 4. An image showing the creation of vortices as water passes around a cylindrical object. Courtesy of Vortex Hydro Energy (http://www.vortexhydroenergy.com).

Michael Bernitsas is the principle investigator in running tests on the VIVACE operating system. The parent company Vortex Hydro Energy (VHE), has designed a prototype VIVACE system. VHE is responsible for refining VIVACE's work product (efficiency), design particulars, mechanical drawings, and instrumentation plan (1).

Bernitsas took a cylinder 10-cm (centimeter) in diameter and 91-cm long with the same average density as water and suspended it horizontally in a bath. He then generated currents between 0.5 and 1.0 m/s. The vortices generated by the flow moved the cylinders up and down. The cylinders were attached to springs that turn an electrical generator (Schirber, 2008). The VIVACE system has undergone various tests with superb results. VIVACE operates at fluctuating velocities of water currents. Maintenance of the system was necessary after six months. The bearings of the cylinders had to be replaced. The bearings on the test system were not new so it is safe to hypothesize that maintenance of the system will be between longer time intervals. All of the above tests were performed in a controlled environment (Bernitsas, 2006). A site in the Detroit River was selected for a VIVACE demonstration of how the system would operate in reality (Giles, 2008). The

description of how the VIVACE system operates is over simplified for comprehension purposes.

The Department of Energy requires that any innovation geared towards harnessing water current energy must: Have high energy density (enables low cost energy to be produced from relatively small installations), be unobtrusive to navigation, be unobtrusive to coastal property, be unobtrusive to marine life, have good robustness, have low maintenance, achieve certain life cycle cost target, and have a design life of at least 10 years (1). According to Bernitsas, the VIVACE system satisfies all of these requirements. Given the overwhelming evidence of the practicality of the VIVACE system, it commercialization and implementation seems inevitable. VIVACE is a zero greenhouse gas emitting wave energy system. VIVACE has been met with very little skepticism.

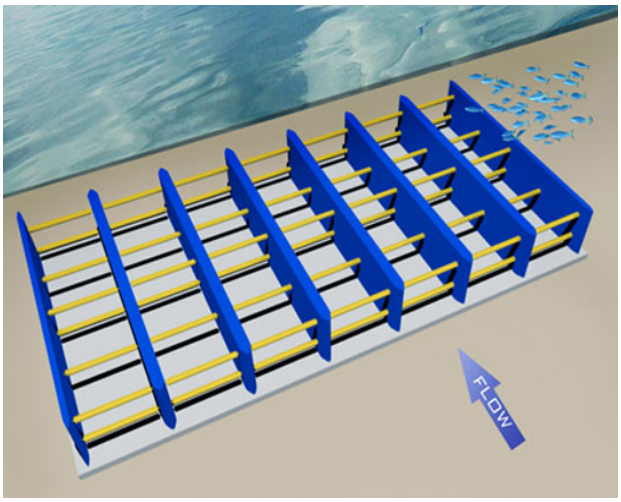


Figure 5. A virtual image of a series of VIVACE systems in operation. Courtesy of Vortex Hydro Energy (http://www.vortexhydroenergy.com).

The major concern about the viability of VIVACE is that the way the system will operate with an uncontrolled environment is unknown (Holzman, 2007). The cost effectiveness of VIVACE will be one of the factors that determine the extent to which it will be commercialized. Environmentalists may have some objections as to where VIVACE units can be placed. Given the fact that more than two-thirds of the planet is covered with water it should not be hard to find areas where VIVACE can be placed while appeasing environmentalist concerns.

Conclusions

VIVACE and AVE are inventions that if implemented, will not have come too soon. The effects of using greenhouse-gas emitting energy sources are far-reaching and devastating. More oil and coal energy production will exacerbate the status of our very fragile environment. The world needs clean energy.

Atmospheric and water Vortices have never been used as a source of clean energy. Despite how intangible the idea of harnessing energy from a tornado sounds, Louis Michaud's idea is just a reflection of the capability of the human imagination. It was this kind of ingenuity that got man on the moon. The same type of ingenuity will solve the world's energy crisis. The challenges facing the AVE are almost insurmountable, but without great risk there can be no great reward. Michael Bernitsas's VIVACE system is a little less audacious and more appealing to the palate. The possibility of having the Niagara or the Hudson River lined with machines that generate clean electricity from the movements of the rivers is very real. The kind of electricity generated by either of these systems is classified as clean because zero greenhouse gases are emitted during energy production. The availability of cheaper energy would reduce the effects of inflation on middle and lower class families. Families would retain more income allowing them to increase their quality of life.

More times than none, nature provides ways to help mankind. The caveman got fire, the renaissance farmer, the wind mill, the plantation owner, hydroelectricity, and the industrial revolution, oil. Vortex energy could be the energy savior of our time. Imagine a world where we get more energy from less raw material consumption. This is the future of vortex energy harnessing mechanisms. Existing technologies allow for the construction of the AVE. In this case, the limitations of the implementation of such a system will be heavily dependent on the political opposition or support for the construction of this system.

It would be very interested to work in the chemical engineering field related to renewable energy production. Vortex energy is relatively unexplored. The development stronger materials to fabricate AVE or VIVACE increases their durability and reduces their maintenance cost. I am fascinated with the idea of contributing to science through research that may increase the energy producing capabilities of vortex energy harnessing mechanisms.

Despite the appeal of AVE and VIVACE, they should be met with some cautious optimism. Nothing is ever as good as it seems, hence it would be smart to anticipate some problems that will be inherent with the application of either system.

Acknowledgements

I would like to thank professors Yoel Rodriguez and William Casari for their assistance in the completion of my research. It would be an almost impossible task to complete this research without their expertise and input. I would also like to thank the Honors Program at Hostos Community College for their support.

References

1. Bernitsas, M. M. (2006). Low Head, Vortex Induced Vibrations River Energy Converter. Retrieved March 3, 2009, from Vortex Hydro Energy Web site: http://vortexhydroenergy.com

2. Chang, R. (2008). Chemistry. New York: Mcgraw-Hill.

3. Cooper, D. (n.d.). The Vortex Engine. Retrieved March 2, 2009, from Vortex Engine Web site: http:// vortexengine.ca/misc/Don-Cooper-The-Atmospheric-Vortex-Engine-1.

4. Delaney, D. (2004). How to increase the electrical output of a nuclear generating plant by 20%. Retrieved February 10, 2009, from Geocities Web site: http://www.geocities.com/davidmdelaney/tornado/Nuclear-plant-imporvement.html

5. Edwards, R. (n.d.). The Online Tornado FAQ. Retrieved February 27, 2009, from Spc.noaa Web site: http://www.spc.noaa.gov/faq/tornado/

6. Giles, J. (2008). River current a new source of renewable energy. Retrieved February 9, 2009, from Ebscohost Web site: http://www.ebscohost.com/ehost/delivery?vid=5&hid=12&sisd=da399377-028c-482c-8ef2-0e...

7. Halliburton, M.-S. (2005). Spinning Power From Waste Energy: Louis Michaud's Atmospheric Vortex Engine. Retrieved February 10, 2009, from Pure Energy Systems News Web site: http://www.pesn.com/2005/12/14/9600210_Atmosphere_Vortex_Engine/

8. Holzman, D. C. (2007). Blue power: turning tides into electricity. Retrieved March 3, 2009, from Environmental Health Perspectiv Web site e: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2137118

9. Michaud, L. (n.d.). Atmospheric Vortex Engine. Retrieved February 24, 2009, from Vortex Engine Web site: http://www.vortexengine.ca/AVE_FAQ.shtml

10. Microsoft Encarta Dictionaries (2009) Retrieved 2009, March 15 from Web site http://encarta.msn.com/encnet/features/dictionary/dictionaryhome.aspx

11. Mone, G. (2007). Twister Power. Retrieved February 10, 2009, from Ebscohost Web site http://web.ebscohost.com/ehost/delivery?vid=10&hid=13&sid=36941443-7512-4168-afaa...

12. Nowak, R. (2004). Power Tower. Retrieved March 21, 2009, from Ebscohost Web site http://web.ebscohost.com/ehost/delivery?vid=11&hid=14&sid=3f41d89b-2e19-48bf-8b02-...

13. Schirber, M. (2008). How Fishy Technology Could Power the Future. Retrieved March 3, 2009, from Livescience Web site: http://www.livescience.com/environment/081203-pf-fish-technology.html

Corresponding author: Yoel Rodriguez
yrodriguez@hostos.cuny.edu

Dear Reader,

Welcome to the first issue of the *Hostos Journal of Student Research* (HJSR)

The following are manuscript guidelines:

Scientific paper (definition).
Scientific paper has to be an original work by a student(s) composed under the mentorship of a faculty member of the Hostos Natural Sciences Department. A mentor's responsibility is to verify data and facts presented in the manuscript, and to avoid possible plagiarism by verifying citation references. Authorship of the paper should reflect the individual contributions of a student/students participating in the implementation of the research project. A mentor has to be included as one of the manuscript's authors.

Scientific essay/literature review (definition).
Scientific essay/literature review has to be an original work by a student submitted to a faculty member of the Hostos Natural Sciences Department. It is the faculty member's responsibility to verify facts presented in the essay, to make sure all conclusions of the essay are supported by scientific data, and to avoid possible plagiarism by verifying citation references. The name of the faculty member who helped the student with writing and editing the manuscript should appear next the student's name.
For example:
Battle with the beasties: are they winning?
John Smith and Olga Steinberg

Submissions
All submissions are to be made via e-mail. Requests for publication should come from the student in the form of a cover letter e-mailed to any member of the editorial board with the scientific manuscript attached in MS Word format. Figures and charts in JPEG format with legends in MS Word format should be sent as separate files. Contact information for both the student and the mentor should be included in the manuscript. Scientific papers and essays previously published/copyrighted elsewhere will not be accepted for publication in the *Hostos Journal of Student Research.*

All manuscript should have an abstract. Abstract is a short summary (less than 200 words) of ideas and conclusions included in the scientific paper.

All references have to conform to APA standard.

Editorial Board:

Olga Steinberg, Editor In Chief	E-mail: osteinberg@hostos.cuny.edu
Francisco Fernandez	E-mail: ffernandez@hostos.cuny.edu
Flor Henderson	E-mail: fhenderson@hostos.cuny.edu
Mohammad Sohel	E-mail: msohel@hostos.cuny.edu

Sample submission letter:

Dear Editorial Board of the *Hostos Journal of Student Research*,

I would like to submit my manuscript (essay) titled…….., authors……..
for publication in the Natural Sciences Department on-line journal *Hostos Journal of Student Research.*
All questions considering the context of the manuscript (essay) should be addressed to me. My contact information……

Thank you for your consideration,
Name…….

Front page photographs:
Morphology of M-Ras KO astrocytes. (A) Immunofluorescence analysis of WT (_/_) and M-Ras KO (_/_) astrocytes. Astrocytes are stained with a Cy3-conjugated anti-GFAP antibody (red), and the actin cytoskeleton at the cell periphery was detected with an antiphospho-ERM antibody (green). Two representative astrocytes are shown for each genotype. Magnification, X60.

Courtesy of Nelson Nunez-Rodriguez

Nuñez Rodriguez N., Lee I.N., Banno A., Qiao H.F., Qiao R.F., Yao Z., Hoang T., Kimmelman A.C., and A.M. Chan. 2006 *Mol Cell Biol*. 26:7145-54.