

A

Seminar report

On

## **Spintronics**

Submitted in partial fulfillment of the requirement for the award of degree  
of Electronics

**SUBMITTED**

**TO:**

www.studymafia.org

**SUBMITTED**

**BY:**

www.studymafia.org

www.studymafia.org

---

## Preface

I have made this report file on the topic **Spintronics**; I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude to .....who assisting me throughout the preparation of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

www.studymafia.org

---

## **Acknowledgement**

I would like to thank respected Mr..... and Mr. ....for giving me such a wonderful opportunity to expand my knowledge for my own branch and giving me guidelines to present a seminar report. It helped me a lot to realize of what we study for.

Secondly, I would like to thank my parents who patiently helped me as i went through my work and helped to modify and eliminate some of the irrelevant or un-necessary stuffs.

Thirdly, I would like to thank my friends who helped me to make my work more organized and well-stacked till the end.

Next, I would thank Microsoft for developing such a wonderful tool like MS Word. It helped my work a lot to remain error-free.

Last but clearly not the least,I would thank The Almighty for giving me strength to complete my report on time.

www.studymafia.org

---

## **CONTENTS**

➤ INTRODUCTION

- Limitations Of Electronics
- Alternatives For Electronics

➤ SPINTRONICS

➤ RESEARCH

➤ REQUIREMENT

➤ SPIN MATERIAL

➤ SPIN DEVICES

➤ POTENTIAL APPLICATIONS

➤ ADVANTAGES

➤ CONCLUSION

➤ BIBLIOGRAPHY

www.studymafia.org

---

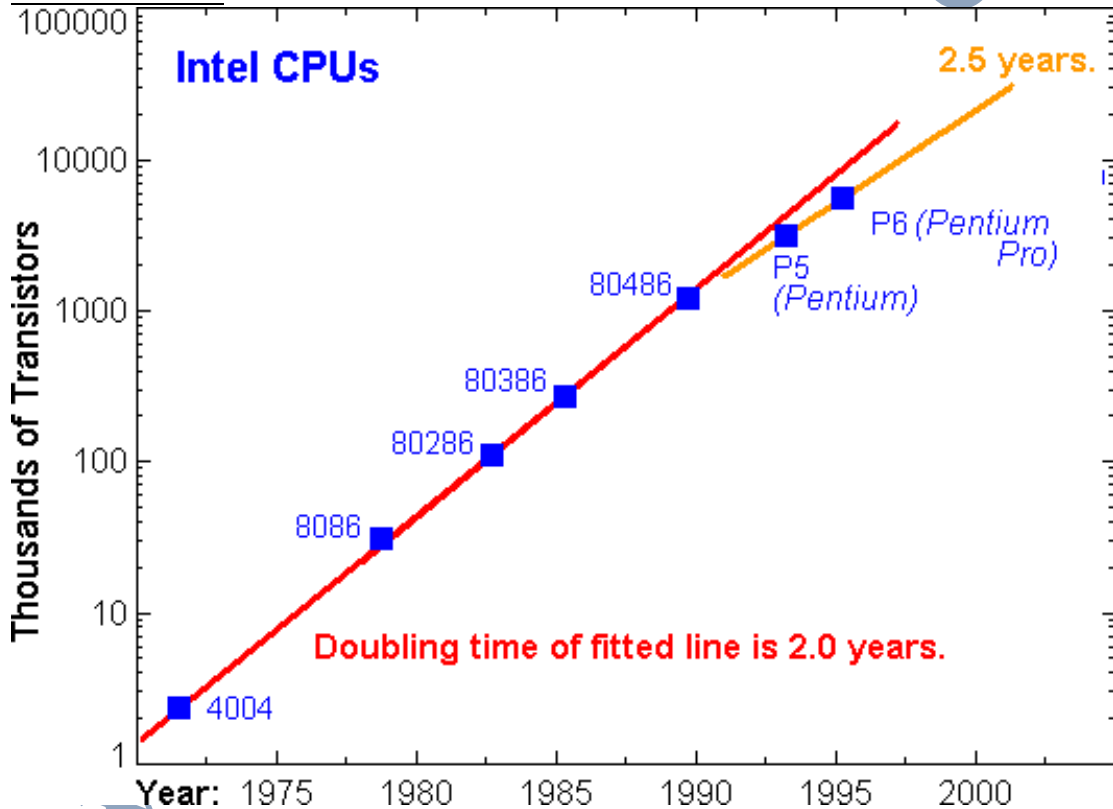
## INTRODUCTION:

### Limitations of Electronics:

Though the field of electronics is considered to be very vast, even his field is attaining its limitations. The two main limitations which is propelling the scientists and researchers new technology are:

- Moore's Law
- Gate Width

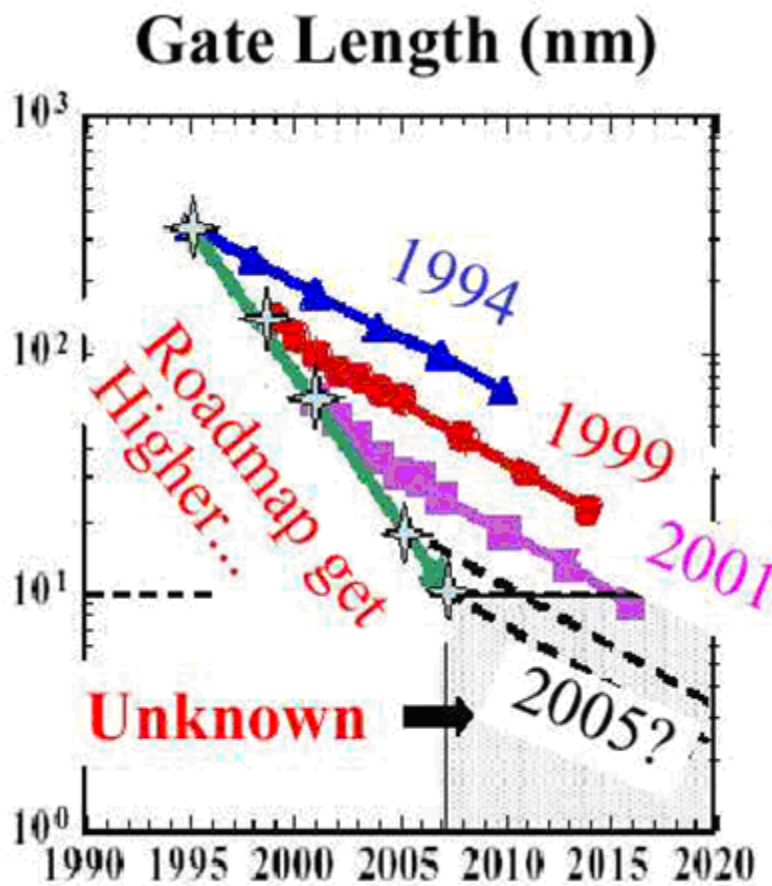
#### Moore's Law:



Moore, one of the co-founders of Intel Corporation, visualized in the early 1970's that the number of transistors fabricated in a single chip will double for every 18 months. Now, after almost three decades, the number of transistors fabricated in a single chip is so large that it places severe demands on the material and fabrication technology used.

Gate Width:

Some scientist and experts have predicted that by the year of 2008, the width of gate electrode in an FET will be around 45nm, which again places severe demands on the material and fabrication technology used. The figure below shows the variation of the gate electrode length over the years.



Alternatives of Electronics:

Due to the above mentioned limitations many alternatives for electronics have been considered such as:

- Bottom down approach of fabrication
- Changing the characteristics of info carriers
- Bio-Electronics
- Polymer-Electronics

- Molecular Electronics
- Spintronics

Of the above alternatives Spintronics has gained prominence because of the fact that spin devices can be fabricated with small variations to present fabrication technology whereas other alternatives require complete replacement of present fabrication units.

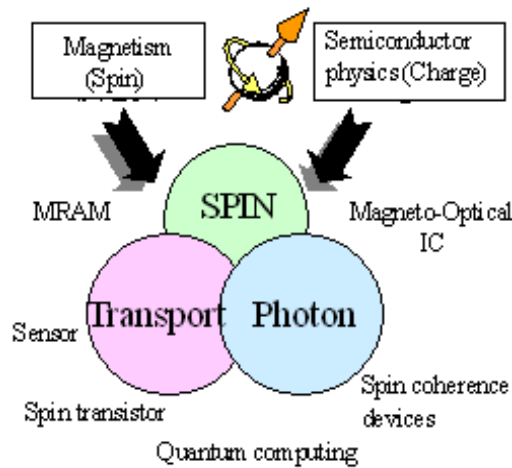
[www.studymafia.org](http://www.studymafia.org)

---

## SPINTRONICS:-

We know that electron will be spinning on its axis. The spin can be parallel or anti – parallel. This spin degree can be used to change the way data is changed or carried. This field of tronics which we in addition to charge of electron, also use the spin of electrons is called SPINTRONICS. Use of the spin provides additional functionalities with increased speed.

### What is “Spintronics”?



### Interplay of the Spin/Charge/Photon makes a new world !

The figure above explains the concept of Spintronics. It shows that the basic properties of the electrons such as spin, charge, photon is used for data manipulation and storage. The interaction between spin, charge, and photon opens a new field called spintronics.

Now, let us see the main differences between electronics and spintronics.

In present electronics, each function required is designed and fabricated in separate chips and these chips are interconnected to obtain desired functionalities. For example, in order to store the data we will use memory unit, to process data we use processor and to transmit/receive data we may use optical fiber.



But, in the case of spintronics basic properties of electron itself is used hence providing multi – functionalities the properties of electrons used for different functions are:

Spin → Data  
Charge → Processing  
Photon → Transmission

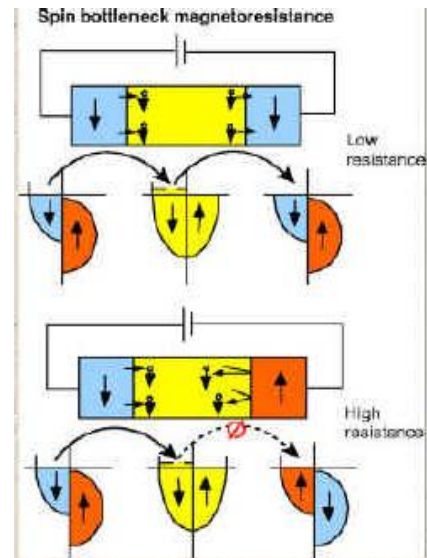
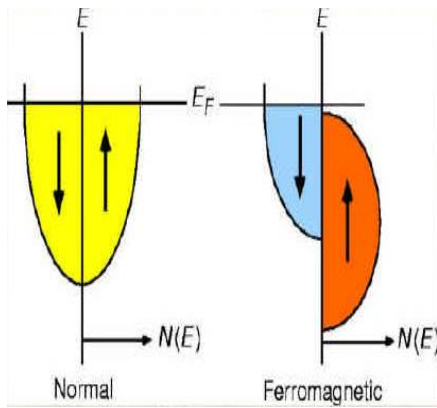
### **RESEARCH AREAS:-**

The scientist have been performing research on some of the field related to spin of electron which will help us to realize the spin devices and spin application into the real world and replace present electronics. The fields of research are:-

- Creation of spin polarization through optical OR magnetic injection.
- Spin polarization transport through semiconductors and super conductor interface.
- Spin relaxation in semiconductors.
- Spin based devices such as PN-junction and amplifiers.
- Spin based quantum computing.
- Feasibility of using phosphorous donor nuclear spins in Si for the purpose of quantum computing and in particular whether SET [Single electron Transistor] can be effectively used as a single electron spin detector.
- Use of NSOM [Near field Scanning Optical Microscopy] to detect electrons in semiconductor quantum dots.
- To detect electron spins using transport experiments, whether electron spin entanglement can be measured using noise correlation measurements, and whether electron spins trapped in gated quantum dots can be used as qubits.

Once the above researches are completed we can start using spin devices. The above fields of research can be understood by analyzing the figure below.

---



The figure in the left shows the spin polarization of electrons in the case of semiconductors and a ferromagnetic material. We are not concerned about spin in semiconductor but we are concerned in the case of ferromagnetic materials.

The figure in the right shows one of the two basic spin devices called MTJ [Magnetic Tunnel Junction]. The MTJ is a device with two ferromagnetic structure separated by a silicon layer.

The electron will tunnel from one layer of ferro - magnet to other. The tunneling factor is dependent on the spin of electrons of both he layers. If the spin of the electrons are in the same direction then the tunneling will be high and if the spin direction is I opposite direction then the tunneling is low.

The MTJ can be used as a PN-junction, the forward bias of the PN-junction is achieved when spin of the electrons are in the same direction and reverse bias is achieved when spin of the electrons are in opposite direction.

The proper operation of PN-junction requires the spin of the electron to change as a function of real-time. This can be achieved by using optical or magnetic injection.

### **REQUIREMENT:-**

The use of the spintronics requires that the materials used to fabricate the spin devices should possess the following requirements to be satisfied by the material:

- Efficient electrical injection of spin – polarized carriers.
- Efficient transmission during transport of carriers through semiconductor.
- Capability to detect or collect spin – polarized current.

### **SPIN MATERIALS:-**

The basic materials used in spin devices for manipulation of spin of electrons are the ferromagnetic which have the capability to change the spin polarization on application of magnetic fields.

The spin materials can be classified into two groups:

- Ferromagnetic Semiconductors
- Half-Magnetic ferromagnets

### **FERROMAGNETIC SEMICONDUCTOR:-**

These are the materials with complete control over the spin electron. The main advantages of these types of materials are:

- Combined semiconducting and magnetic properties for multiple functionalities
- Easy growth of ferromagnetic-semiconductor nanostructures.
- Easy spin injection

As name suggests the half – magnetic ferromagnets doesn't have full control over spin of the electrons.

The spin materials can be obtained as:

Substitution of V, Cr and Mn into GaAs, InAs, GaSb, GaP and INP.

---

## SPIN DEVICES:-

There are basically two spin devices which have been fabricated in industries and verified its working. They are:

- GMR [Giant Magneto Resistance]
  
- MTJ [Magnetic Tunnel Junction]

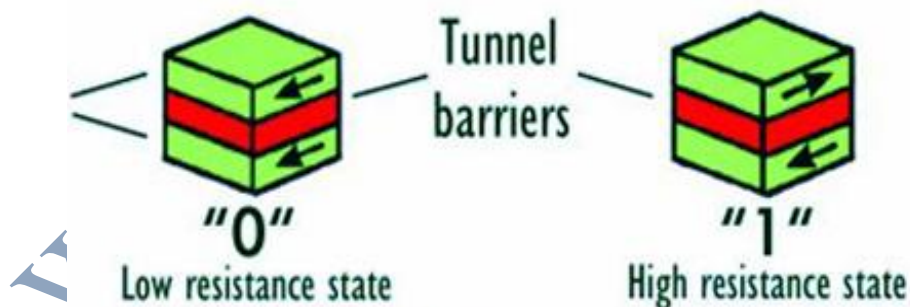
### GMR: - [Giant Magnetic Resistance]

This was the first device manufactured in the industries and is used in almost all commercial electronic equipments. The structure of GMR is very simple with alternate layers of ferro magnetic and non – magnetic layers.

GMR works depending on the orientation of the electrons in the ferro – magnetic layers. The resistance of the GMR device varies depending on the spin orientation. The resistance is high when the orientation of spin is anti-parallel and is low when the spin orientation is parallel.

### MTJ: - [Magnetic Tunnel Junction]

This device is not yet used in the industries but will soon its application. The structure of MTJ is very simple with two Ferro magnetic layers separates by a semiconductor layer.



The figure shows the structure of MTJ. As said earlier the direction of spin decides the resistance of the device. The Semiconductor is often called Tunnel Barrier as it acts as the barrier between two ferro magnetic layers. If the resistance is high then the number electrons tunneling are low and if the resistance is low then the electrons tunneling are high.

### **SPIN APPLICATION:-**

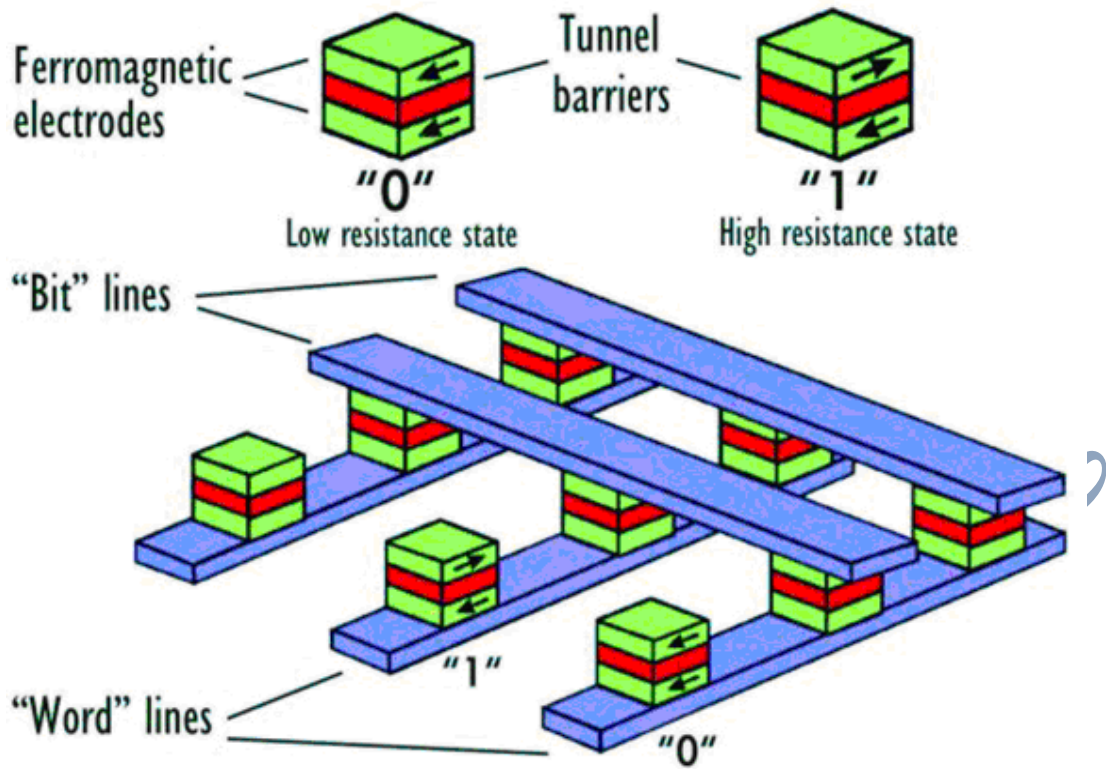
The applications of spin devices and hence spintronics are vast since it provides many advantages such as speed and size. Since so far only two spin devices [GMR and MTJ] have been proposed, the applications are based on these two devices. Some of the potential applications are:

- Spin LED
- Spin FET
- MRAM

### **MRAM:-**

The MRAM is the form of the RAM and is acronym for Magnetic Random Access Memory. MRAM basically uses a spin device known as Magnetic Tunnel Junction. The property of Tunnel magneto resistance [MTR] of the MTJ is used in MRAM. The relative change of MTR can reach 70% at room temperature. The figure below shows the structure of the MTJ as well as MRAM.

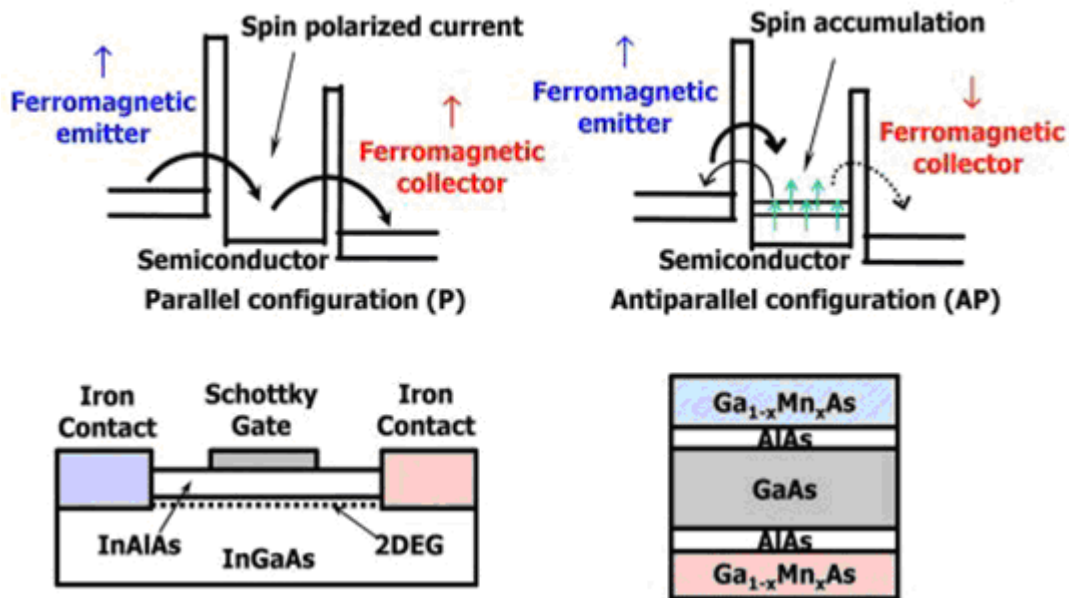
---



The MRAM is presently under development and is expected to reach similar densities and access times as the current SRAM and DRAM, but their main advantages on these volatile semiconductor- based memories is that they retain data even after losing power and hence to helps to decrease the boot – up time of computers.

As shown in the figure each junction can store a bit of data. If the polarization of spin is in parallel at both the layers, the resistance will be less and we say that a bit "0" is stored. And if the spin polarization is anti – parallel then resistance is high and we say a bit "1" is stored. The main advantage of MRAM is that it can attain a writing speed of 1000 times to that of the present RAM's.

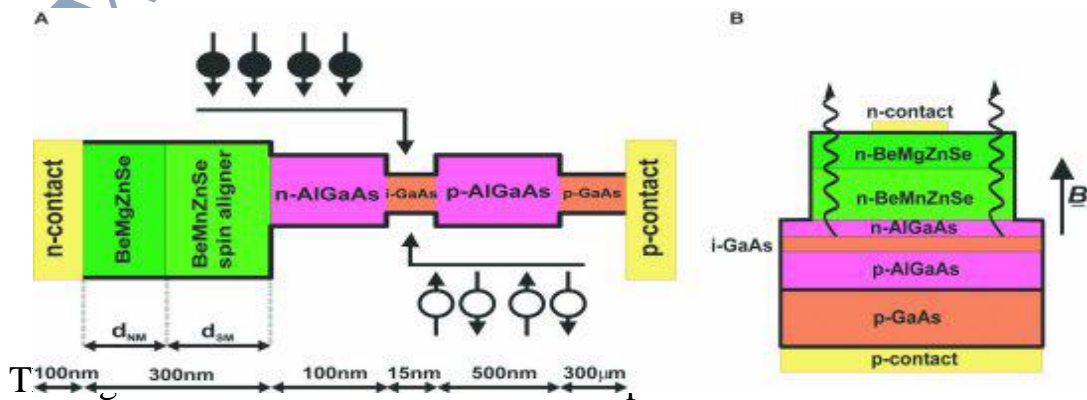
**SPIN FET:-**



The figure above the structure and working of Spin FET. As shown the Source and Drain areas are fabricated using ferro-magnetic material and the channel is fabricated using the semiconductor material. The additional gating effect is via the magnetic field.

The working of the spin FET is illustrated in the upper part of the figure. It illustrates the physics of devices where both injection of spins into semiconductor and detection of spin information are electrical. The ideal situation is when the spin lifetime is much longer than spent by the carriers in semiconductor. As shown a spin polarized current is then easily transmitted in the parallel configuration of emitter and collector, whereas the anti-parallel one leads to spin accumulation and current blockade.

**SPIN LED:-**



heterostructure as shown. Spin – polarized electrons are injected from a

paramagnetic DMS into a GaAs/AlGaAs LED, which leads to emission of circularly polarized light. An injection efficiency of 90% spin polarized current has been demonstrated with this structure.

### **ADVANTAGES OF SPINTRONICS:-**

As most of the spintronics devices/applications are on paper all the advantages are just defined based on theoretical findings and they may have some dis-advantages which will/may be known after they are fabricated and used. Some of the advantages of spintronics are:

- ✓ The spin devices act as multi-functional units.
- ✓ The spin devices and hence spin applications can be realized by making some changes to the present fabrication technology.
- ✓ Its easy to grow spin layers. i.e. its very easy to grow alternate layers of ferromagnetic and semiconductor materials.
- ✓ The MRAM has all the properties of DRAM SRAM and ROM and hence single memory chip can be used instead of three memory chips.
- ✓ As said using single spin chip we can store, process, and transmit the data whereas in present electronic chip this is not possible.



## **CONCLUSION:-**

In this report we have seen the advantages of spintronic devices over the present electronic devices. As said earlier this is the technology which will replace the present electronics era and provides the advantages of speed, size, compactness so on. If the applications such as LED and MRAM can be realized we can attain high efficiency of output in the case of LED and we can attain high writing speed and reading efficiency in the case of MRAM. Though the area of spintronics has some drawbacks which will be realized when the spin devices will be fabricated we may still avoid these drawbacks to large extent.

One drawback of this emerging technology is that since the spintronics is mainly based on the magnetic properties of the material, the magnetic field of the earth may affect the magnetic field inside the spin devices and cause errors. One main disadvantages of this is that the data stored in a MRAM may be altered and hence can lead to errors.

Hopefully, this and many unknown effects will be found out and efforts are made to avoid such effects and lead to more reliable, more functional, with greater speed of operation of spin devices will be achieved.

## References

- [www.google.com](http://www.google.com)
- [www.wikipedia.org](http://www.wikipedia.org)
- [www.studymafia.org](http://www.studymafia.org)

www.studymafia.org

---