# Electronic Cooling by LASER

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## ABSTRACT

Even in the age of green computing and lower power manufacturing technology, thermal management, specifically heat mitigation continues to be a challenge. That is the heat produced in the semiconductor is the main problem faced by the design engineer. When a junction temperature of semiconductor rises above its max allowable temperature, there is a need to dissipate this temperature or else the device will break down. a semiconductor device include an intermediate layer moderates thermal stress resulting from a difference between the thermal expansion of the semiconductor element and thermal expansion of the heat sink arising due to heat produced by the semiconductor . This paper deals with laser cooling. Which provide an efficient heat transfer from the device to the environment. Cooling systems an important part of any e device

**Key words**: **laser cooling, Magneto-Optical Trap**

## I. INTRODUCTION

Conventional wisdom holds that the laser light directed at any object will heat rather than cool the object. But at certain circumstances lasers can be used to efficiently cool the objects. Laser cooling is based on the principle of physics known as anti-stokes fluorescence and occur when the amount of energy emitted by a solid, when exposed to an energy source, is more than the energy it absorbs. In other words laser aimed at certain materials will excite the material atoms to a higher energy level state. These excited atoms absorb a little extra energy from the heat of the surrounding material when they produce photons, the photons are of a higher energy than the initial laser energy and this radiation of energy cools the material.

Electromagnetic interaction can be used to act on the atoms, to manipulate them to control their various degrees of freedom. With the development of laser sources, this research field has considerably expanded during the last few years. Methods have been developed to trap atoms and to cool them to very low temperature.

A new technique for meaning the transverse profile of ion beams using laser induced fluorescence is presented. The technique employs the resonant interaction of laser light with a beam of circulating ions in a storage ring. The light from the spontaneous decay of the excited ions is imaged by an optical system on to a high resolution CCD making it possible to extract the beam's transverse spatial distributions. The first results from this technique including studies of the transverse to longitudinal coupling in a circulating laser cooled ion beam. With the advent of VLSI technology the heat dissipation in the circuit has gone up many folds with every new design. So nowadays, the semiconductor industry is facing the problem of fast removal of heat from the chip and the system. The problem of heat removal from the electronic chip is an old one. However recently it has become very prominent due to increasing numbers of circuits being packed into a single chip and at the same time the dimensions of the chip are also shrinking. This is resulting in the heating up of chips and consumption of more power. In light of the ongoing developments in the area of electronics.

The need for new cooling techniques is driven by the continuous increase in power dissipation of electronic parts and systems. In many instances standard technique cannot achieve the required cooling performance due to physical limitations in heat transfer capabilities. In all cooling application, heat from the device must first travel via thermal conduction to the surfaces exposed to the cooling fluid before it can be rejected to the coolant

The Figure 1 shows heat must be conducted from the chip to the lid to the heat sink before it can be rejected to the flowing air. In many cases heat spreader is in the form of a flat plate with good thermal conductivity may be placed between the chip and lid to facilitate spreading of heat from the chip to the lid or heat sink

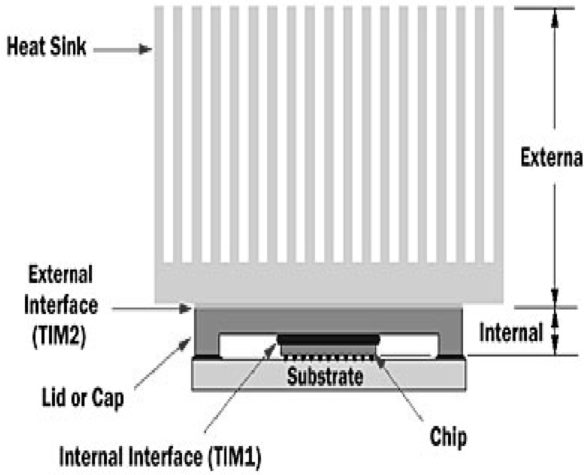

**Figure 1. Example of heat sink**

But for high power application the interface thermal resistance becomes an important issue. A synthetic jet cooler contains a synthetic jet contains cool air from ambient impinges on the top hot surface and circulates the heated air back to the ambient through the edges of the plate. A radial counter current flow is created in the gap between the plates with hot air dispersed along the top and ambient air extrained along the bottom surface. The idea was further explored by the development of flow actuators using MEMS technology.

## 2. LASER COOLING

Laser cooling and tapering of neutral atom is a rapidly expanding area of physics research that has seen dramatic new development over the last decade. These include the ability to cool atoms down to unpredicted kinetic temperature( as low as 1micro kelvin) and to bold samples of a gas isolated in the middle of a vaccum system for many second The primary force used in laser cooling and traping is the recoil when momentum is transferred from photons scattering off an atom. This radiation pressure force is analogous to that applied to a blowing ball when it is bombarded by a stream of ping pony balls. The momentum kick that the atom receives from each scattered photon is quite small; a typical velocity change is about 1cm/s. However by exciting strong transition, it is possible to scatter more than 107 photon/second and produce large acceleration. The radiation pressure force is controlled in such a way that it brings the atom in a sample to a velocity near to zero(cooling) and holds them at a particular point in space(trapping).The cooling is achieved by making the photon scattering rate velocity dependent using the Doppler shift as shown **Figure 2**

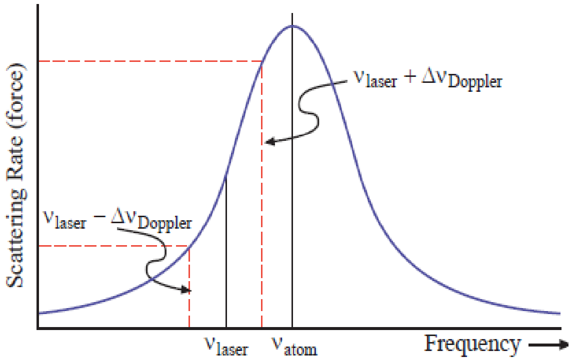

**Figure 2. Principle of Doppler Effect**

If an atom is moving in a laser beam, it will see the laser frequency u laser is shifted by an amount – (u/c)vlaser where v is the velocity of atom along the direction of the laser beam. If the laser frequency is below the atomic resonance frequency, as a result of Doppler shift an atom will scatter photons at a higher rate if it moving toward the laser beam than it is moving away. If the laser beam impinges on the atom from all the six direction, shown in Figure 3**,** the only remaining force on the atom is the velocity dependent part which opposes the motion of the atom. This provides strong damping of atomic motion and cools the atomic vapour. This arrangement of laser field is known as optical molasses, atom will scatter photons at a higher rate than those moving in the same direction as the beam. This leads to a larger force on the counter propagating atoms.

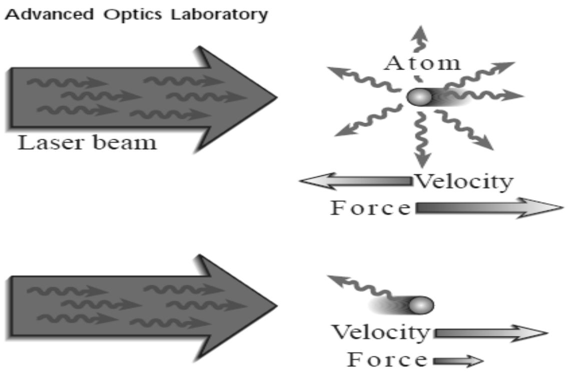

**Figure 3. Laser cooling**

The combination of laser cooling and atom trapping has produced new tools for atomic physicist. These experiments require the exchange of momentum between atoms and an optical field, usually at a nearly resonant frequency. The energy of light hω changes the internal energy of the atom. The force resulting from the momentum exchange between the light field and the atom can be used to control the atomic motion, thus slows down the aton and cool it.

Laser cooling is a successful technique for creating high brightness atomic source for various applications. Doppler cooling which represent the dominant mechanism at all but the lowest velocity is based on the preferential scattering of photons from a laser beam opposing the atomic motion into a random direction. In particular, molecules have a large number of vibrational and rotational states that cannot be addressed by the same frequency, while each of the many transition carries only small transition strength. Once the molecule is optically pumped into a different internal state, it no longer interacts with the light and the cooling ceases

## 3. Magneto-Optical Trap [MOT]

Although optical molasses will cool atoms, the atom will still diffuse out of the region if there is no position dependence to the optical force. And MOT is also known as ZOT, Zeeman shift Optical Trap. Though Zeeman shift of the atomic energy level, the magnetic field regulates the rate at which an atom in a particular position scatters photons from the various beam and there by causes the atoms to be pushed to a particular point in space. In this simplified case we consider an atom with J=0 , ground state and J=1, excited state, illuminated by circularly polarized beams of light. Because of its polarization, the beam from the left can only excite transition to the m=+1 state, while the beam from the right can only excite transition to the m=-1 state. The magnetic field is zero in the centre, increases linearly in the positive X direction and decreases linearly in the negative X direction. This field perturbs the energy levels so that the ⌂m=+1 transition shifts to lower frequency. If the atom moves to the left of the origin while ⌂m=-1, transition shifts to higher frequency. If the laser frequency is below all the atomic transition frequencies and the atom is to the left of the origin, many photons are scattered from the □ laser beam because it is close to origin. Thus the force from the scattered photons pushes the atom back to the zero of the magnetic field. If the atom to the right of the origin, exactly the opposite happens and the atom is pushed toward the centre where the magnetic field is zero

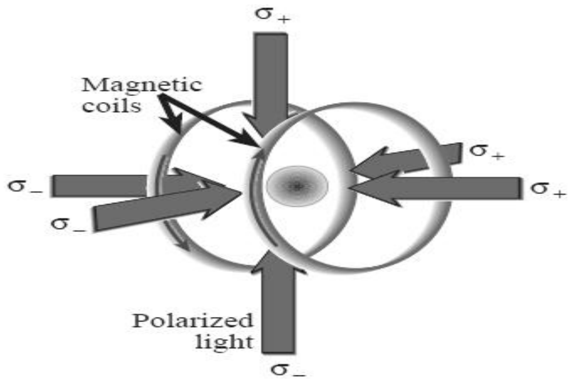

**Figure 4.MOT**

## 4. CONCLUSION

Thus laser cooling systems work far more effectively at cooling these hot chips into cooler ones, hence allowing the transistors to continuously change states even faster. The liquid extracts the heat far more efficiently than just air. Manufactures put a temperature limit on a chip, handicapping their capability to achieve higher rates of activity; with a air coolant a normal activity is achieved but with a liquid coolant the chip is allowed to continue for longer periods of time thus achieving higher rates and increasing efficiency

## 5. REFERENCES

[1] . Laser cooling and trapping ,Advanced optical laboratory

[2]. Optical probing of Cold trapped atoms, R W Fox, S L Gilbert, J H, Marquardt and H.G Robinson ,Opt.Lett..Vol. , 18,No.17,pp. 1456-1458(1993)

[3] Laser cooling and Trapping of Nutral atom, H.J.Metcalf, Peter van der straten

[4.] Laser cooling of Atom, Ion, Molecules bu Coherent scattering, Vladan and Steven Chu, Department of Physics, Stanford university, Stanford

[5]. Laser cooling using electro magnetically induced transparency , Quantum Electronics and Laser science Conference 2000, issue date:7-12 May 2010

[6]. Laser cooling of internal molecular degrees of freedom Decision and Control 2000, Proceedings of 39th IEEE conference

[7]. Band gap engineering for laser cooling of semiconductor issue date: Dec.2006