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A Novel Approach to Electromagnetic Interference Shielding for Cell Phones

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Abstract: ***The electromagnetic radiations penetrate through the human body. These radiations of cell phones cause heating of body fluids resulting in de-hydration of brain cells and surrounding tissues. This is the major health problem in the era of communication. This paper discusses different methodologies for electromagnetic shielding that will inhibit the penetration of severe electromagnetic radiations through the brain. These methodologies cover shielding by aluminium foil/mesh, thin graphene layer, combination of polystyrene and carbon nanotubes, layers of non-metal and dielectric.***

Keywords: Electromagnetic Interference, Electromagnetic Shielding, Carbon nanotubes

1. Introduction

In this modern era of communication, the range of communication has increased to a broader extent. Due to this the power level of communication system also got shifted upwards. This has strengthened the electromagnetic radiations by cellular phones leading to various health problems. Not only humans but also other living organisms are affected by these strengthened radiations. This has created disturbance to biological cycle.

Power transmitted by personal communication devices such as cellular phones, and partly absorbed by the body, is of great concern for two reasons. It is the brain, the most critical organ in the body,that absorbs the large fraction of power and are used for hours per day by a very large number of people [9].

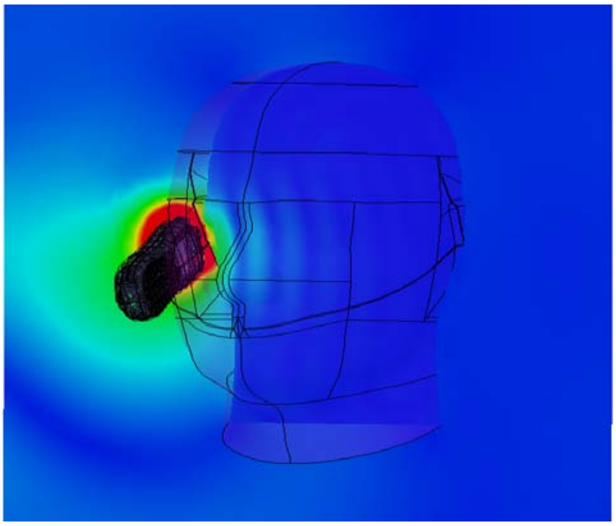

Figure 1: The EM radiation spectrum around the ear by a cell phone

The local Specific Absorption Ratio is defined as-
SAR= $0.5*\sigma E^2/\rho$

Where, σ denotes electrical conductivity in S/m, E is the magnitude of peak electric field in V/m and ρ is the mass density in Kg/m^3. The unit of SAR is Watts/Kg [9].

SAR is measure of the rate at which energy is absorbed by the human body when exposed to electromagnetic field, although, it can also refer to absorption of other forms of energy by tissues.

The solution for this problem is minimizing the radiations by absorption and/or reflection of the electromagnetic radiations which penetrate through the body. The Electromagnetic Interference (EMI) shielding refers to the reflection and/or absorption of electromagnetic radiations by material, which there by acts as a shield against the penetration of the radiations through the shield. As electromagnetic radiations are particularly that at high frequencies (e.g. Radio waves such as those emanating from cellular phones) tends to interfere with electronics. The block diagram gives the basic idea about such shielding.

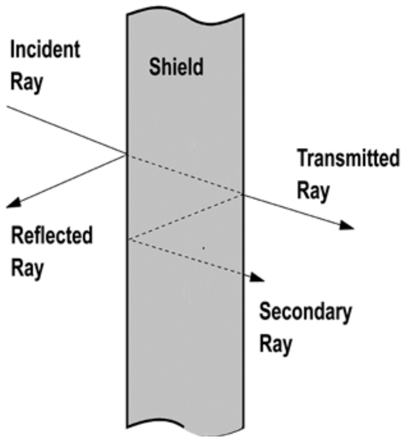

Figure 2: Block diagram of EM shielding

The electromagnetic radiations of antenna are omnidirectional. To protect any object from penetration of such EM radiations, we need to introduce such type of shield between object and source of the radiation. The exposure of object to the radiations is minimized because of reflection and absorption by the shield. The transmitted radiations through the shield aresufficient for communication purpose and are very less harmful to the object. Our area of interest is to apply this concept in personal communication devices like cell phone.

2. Methodologies

Magnetic shielding is very vast research arena. Many shielding techniques have been developed for protection of objects from these radiations. Literary research and our design work suggest that following techniques are beneficial concerning the adverse effect on the living organisms.

A. Electromagnetic shielding using Aluminium foil

The shielding effectiveness of aluminium foil depends upon the type of incident field, the thickness of the foil, and the frequency. Shielding effectiveness is usually broken down into reflection and an absorption loss. Although aluminium is non-magnetic, it is a good conductor, so even a thin sheet reflects almost all of an incident electric wave. At frequencies less than 100 MHz, the electric field is attenuated. Thin sheets of aluminium are not very effective at attenuating low frequency magnetic fields. Thin shields also have internalreflections that reduce the shielding effectiveness. For effective shielding from a magnetic field, the shield should be several skins depths thick. Aluminium foil is about 1 mil(25µm); thickness of 10 mils(10 times thicker) offers less than 1 dB of shielding at 1 KHz, about 8 dB at 10 KHz, and about 25 dB at 100 KHz. The foils are easy to work with and offer good shielding effectiveness across a wide range of frequencies. It can be used to form shielded enclosures of almost any size or shape. Following table describes the attenuation of EM radiations by aluminium foil[14].

Table 1: Shielding effectiveness

Sr. No.	*EMI shield effectiveness using Al foil*		
	Frequency	*Field*	*SE(dB)*
1	100 KHz	Magnetic	≥10
2	1 MHz	Magnetic	≥20
3	10 KHz	Electric	≥60
4	100 KHz	Electric	≥60
5	1 MHz	Electric	≥65
6	100 MHz	Plane Wave	≥45
7	400 MHz	Plane Wave	≥40
8	10 GHz	Plane Wave	≥40

Thus the aluminium foil can be used as shielding material but it has many drawbacks. The graph below shows the relation between electromagnetic shield properties and the frequency.Aluminium foils are light weight¸thin¸ highly conductive, strong reflector of radiations but the major drawback is it's thickness. It also traps heat causing excessive heating of the foil leading to contraction of the metal. Hence the aluminium foils are not reliable.

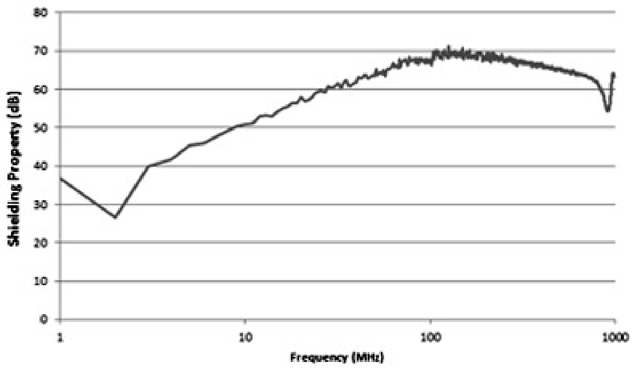

Figure 3: Shielding Property and Frequency Representation
The best solution is to replace the foil by natural rubber which has low dielectric constant and high shielding properties.

B. Electromagnetic shielding using Carbon nanotubes (non-metal) and polystyrene(Thermocol, dielectric)

Polymer composites filled with carbonnanotubes have been intensively investigatedin recent years with the aim of improving the composites' mechanical properties for shielding purpose. In addition to the exceptional mechanical properties associated with carbon nanotubes, they also exhibit superior electrical properties. Combined with their remarkable mechanical and electrical properties, carbon nanostructures possess another intriguing characteristic—low density, which will offer a lightweight structure for electromagnetic interference (EMI) shielding. Multi-walled carbon nanotube–filled polystyrene composites were fabricated by an ultrasonic dispersion-spraying technique. A series of carbonnanotube–filled PS composites was synthesized with different carbon nanotube loadings. The thickness of test samples for EMI shielding measurement was 1 mm[6].The same ultrasonic dispersion-spraying technique has been used to fabricate multi-walled carbon-nanotube filled paper composites. The dielectric constant of the paper is 3.0 and that of polystyrene is 2.6.The permittivity is often expressed in terms of the permittivity of free space, $\mathbf{e_0}$, in terms of the dielectric constant K.

$\varepsilon = K*e_0$

By this relation, it is clear that; dielectric permittivity is directly proportional to the dielectric constant. Thus, for better attenuation we need material of the lesser dielectric constant. Carbon nanotube–filled polystyrene composites were fabricated for EMI shielding in the frequency range of 8.2 12.4 GHz [6].The results showed that the EMI shielding effectiveness of composites was essentially independent of frequency in the measured range, and increased with increasing carbon nanotube loading. The multi-walled carbon nanotube–filled PS composites were found to be more effective in providing EMI shielding compared to paper–filled PS composites at the same filler loading. Furthermore, carbon nanotube–filled PS composites exhibited high shielding.

C. Electromagnetic Shielding Using Graphene

CVD-synthesized graphene shows more than seven times greater EMI shielding effectiveness than gold film of the same thickness. Feasibility of manufacturing an ultrathin, transparent, weightless, and flexible EMI shield by a single or a few atomic layers of graphene makes it a better shielding material. There have been experimental reports and theoretical analysis about the shielding effectiveness of graphene. But in these previous works, the researchers used graphene flakes obtained by the reduction of graphene oxide, not a single layer graphene as in this method [12].

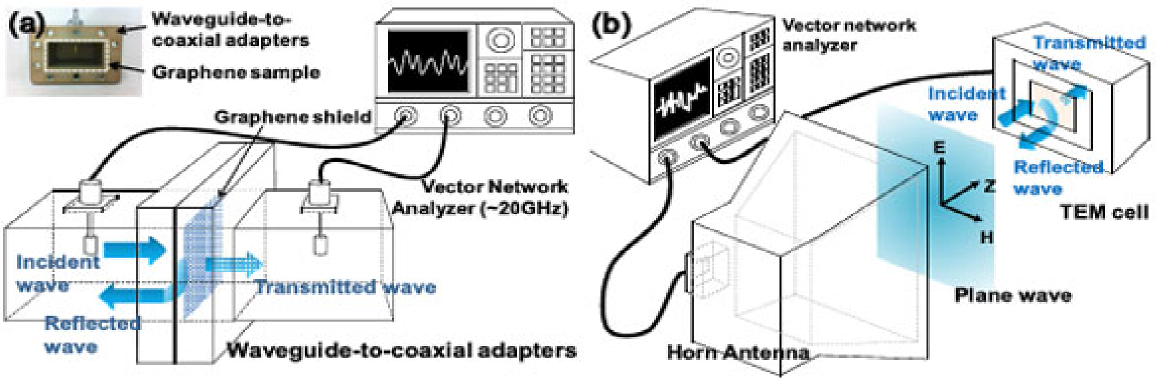

Figure 4: Schematic drawings of the measurement setup for the electromagnetic interference shielding effectiveness of graphene

The highly conductive graphene may cause heating problems which can damage the device. But this problem can be cured by making the graphene layer the black body so that it will absorb maximum of heat radiations itself. 97.8% shielding is possible by using ideal monolayer graphene. Actual CVD-synthesized graphene is 40% efficient [12].

3. Implementation

The graphene methodology discussed in this paper is superior to the others. We have implemented this technique theoretically for shielding of cell phones. This shielding will surely supress the effect of electromagnetic radiations on brain cells and will minimize the brain disorders.

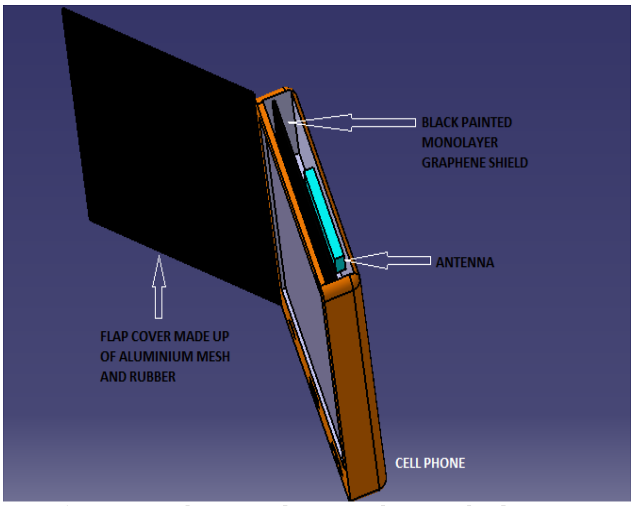

Figure 5: Schematic diagram showing body parts.

The basic need is to induce a shield between cell phone antenna and human ear. The antenna is located just below the display of the cell phones. The black painted monolayer graphene shield is placed on the antenna below the display. The backside of the antenna is kept unshielded for the communication purpose. Today's smartphones use flap covers as the safety measure for the screen and display. Modifying these flap covers we have minimized the intensity of transmitted radiations using the monolayer graphene. The flap covers are constructed using aluminium mesh covered with rubber. The natural rubber is used because it acts as an effective shield for radiations in the range of 8-12 GHz [5].

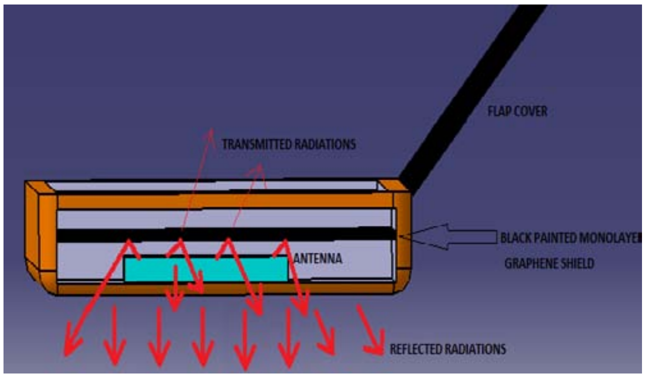

Figure 6: Schematic diagram showing working

The antenna is omnidirectional. Due to the shield maximum of the radiations are absorbed and/or reflected. The transmitted radiations are further shielded by flap cover used in the design. Thus shield actually minimizes the radiations passing through the brain cells and nearby tissues. So the damage to the cells due to heating of cellular fluids is restricted.

4. Conclusion

The electromagnetic radiations penetrating through the brain are minimized to 40%. The material gets heated due to the conductivity property and is painted black. The liquid form of carbon nanotubes holds any dielectric material effectively. Hence increasing its shielding properties. The flap covers for cellular phones are designed using aluminium mesh and rubber which will block the minute transmitted radiations from the shield. Considerable work is still needed to improve further shielding effectiveness as well as mechanical properties of conducting polymer based composites.

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