

PROTECTION OF COMMUNICATION SYSTEM FROM SOLAR FLARES

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ABSTRACT

Solar flares are enormous explosions on the surface of the sun and they release energy of the order of billion megatons of TNT. This energy is in the form of electromagnetic radiations such as alpha, gamma, and ultraviolet rays. When exposed to high doses of radiation like 2-15 kilorad (Si), silicon integrated circuits in satellite communication systems fail to operate properly, thus affecting the performance of communication systems. Therefore, the major issue that needs to be addressed is the protection of integrated circuits and their survivability when they are exposed to various space environmental hazards including high doses of electrons, protons, solar flares and other cosmic radiations. In this paper, we present a survey of novel approaches whose effectiveness in protecting communication systems in space against solar flares has been demonstrated. In particular, we explore high Z materials used to form a radiation shielding that acts as a grit-blasted screen and low Z carbon nanotechnology used to protect against protons. We also make observations regarding a 3D layered coating for improved shielding, the use of commercially available substances, and additional ionizing radiation resistance to virtually sensitive electronic devices.

INTRODUCTION

Space exploration has been increasingly dangerous to our astronauts and electronics during our venture into space. The space environment has three sources of radiation: Galactic Cosmic Rays (GCR), solar energetic particles, and particles within the Geomagnetic field. Exposure to radiation during solar flares has adverse effects on long duration missions and exceeds the total dose limits allowed for astronauts during their lifetime. If more effective radiation shielding can be developed, the personnel and electronics would be able to withstand the hazardous space environment for a longer period of time without increased risk. Many materials have been investigated, and research for a cost-effective material that would reduce the effects of energetic protons from GCR is continuing.

Desired materials would need to be lightweight to keep the transport of such

material cost effective on long missions. In addition, materials with a high hydrogen density are preferred, because the use of hydrogen materials also reduces the spallation fragments associated with higher Z atoms. These fragments can increase radiation damage to personnel and electronics. Materials with structural properties that are radiation resistant are also needed for future spacecraft.

This paper describes some novel methods for protecting the communication systems (satellites, broadcasting stations, etc.) and space-crafts from the effect of high amount of radiations caused due to solar flares. The methods described have been chosen based on their reported success in meeting the following needs:

- 1) Protect satellites and other communication systems in space;

- 2) Protect space craft from tearing off due to radiation and highly hazardous aerospace environment;
- 3) Protect humans involved in explorations in space;
- 4) Store fuels.

We have learned that all the above needs can be fulfilled with the help of carbon nanotubes (CNT) for almost all types of radiations. For thermal protection, a grit-blasted screen has proven to be most useful.

CARBON NANOTUBES (CNT)

After many decades of using methods that are not very efficient for purposes of protecting both the interior and exterior parts of communication systems, the use of carbon nanotubes (CNT) for protection against radiations has gained considerable attention in recent years due to several reasons [1].



Figure 1
Schematic Representation of Carbon Nanotube Structures [6]

First, their provocative geometry (Figure 1) permits the formation of hydrogen filled composites that could be used for spacecraft structure, radiation shielding for many instruments like satellites, and fuel storage. A schematic representation of CNTs is shown in Figure 1.

Second, CNTs have also been studied for their hydrogen absorption capacity, their

ability to serve as strengtheners in composites, and their potential use in other aerospace applications. In particular, a great deal of work has also focused on investigating the tolerance of these materials to radiation environments relevant to aerospace missions.

Many experiments conducted by various research agencies have repeatedly demonstrated that CNTs have a bright future ahead in space-based explorations due to the following characteristics of CNTs:

- 1) Resistant to heat;
- 2) Tolerance for large quantities of radiations [1];
- 3) Excellent electric conductivity;
- 4) Ability to withstand any environment;
- 5) Ability to withstand heavy weights.

CNT RADIATION SHIELD

The radiation-hardened processor that is currently used for space is not adequately resistant to the high levels of radiations caused by solar flares. For instance, a processor for use in space is expected to withstand a maximum of 1 Mrad (Si) of total dose of radiation [1]. The single walled nanotube (SWNT) is the most effective and efficient of the various methods of using CNT in space because it has been experimentally verified that [1]:

- 1) SWNTs have a high resistance for the high amount of radiations that are caused by solar flares;
- 2) SWNTs can withstand radiation in the range of 800MeV caused by proton penetration.

Therefore, it is evident that CNTs can be efficiently used for space satellites and for other broadcasting stations in space.

CNT AS SOLAR CELLS:

It is important to note that CNTs can also be used as excellent solar cells. The advantages of using CNTs as solar cells are their reduced size, weight, and their high resistance to radiations of solar flares. These advantages make CNTs five orders of magnitude more efficient than the solar cells presently in use. Another advantage of using CNTs as solar cells is their ability to store large quantities of hydrogen that is characteristic of metal hydrides. CNTs are capable of storing anywhere from 4.2% to 65% of their own weight in hydrogen [2].

GRIT-BLASTED SCREEN

Commonly known by the name grit-blasted tungsten, a grit-blasted screen acts as an aperture shield for solar cells during solar flares. Also, because of its low specular reflectance, it can be used to protect the communication systems from heat, even at the level that is produced at high temperatures of the order of 2000°C. Coupled with the use of CNTs, the grit-blasted screen will provide for a much higher level of protection against heat [3].

CNT MADE CIRCUITS

CNTs are also capable of replacing electrical circuits, while reducing their size considerably. As the circuits shrink and transistor volumes become smaller, the charge that is required to cause an upset in the circuit element decreases [4]. Therefore, the CNT made nano-circuits are more efficient and safer than any other circuits that are presently in use.

CNT MADE MICRO AMPLIFIERS

It is also necessary to protect micro amplifiers as they play an important role in transmitting a signal from the satellite. The current amplifiers use hot cathode technology, while studies made by Ken Teo and his team at University Of Cambridge shows that CNTs use cold cathode

technique [5]. Moreover, a single cathode consists of approximately 2,500 nanotubes, spaced apart at twice their height to give maximum electrostatic protection.

SOFTWARE ALTERATIONS

The penetration of high energy particles into the circuit causes the single event effects. Here, the electrons and other energetic particles act as virtual wires, which produce spurious currents. Studies say that, the data in the circuits may get altered from 1 to 0 and vice versa, due to a single event effect. The remedies for such situations have been identified as innovative design methods using voltage logic, error checking, latchup circuits [4, 5].



Figure 2
Latchup Correction Technique

In the voltage logic method, three latches are used to determine the output so that an alteration could occur only with the rare occurrence of two simultaneous errors. In error-checking circuits, an extra check bit is used on interrogating, which an error may be detected and rectified [5]. Finally, in the latchup method, a latch is represented at two nodes thereby avoiding an upset due to a strike at any single node.

Figure 2 shows an implementation of the latchup correction technique. The single register can be replaced by a more complex circuit. The same GREEN information is stored in 3 independent registers and checked by the voting cell. The output of the voting cell remains true (GREEN) even if

one of the registers loses its information (to RED) by being hit by a heavy ion. The output of the voting cell always reflects the majority of its inputs. All registers will be restored by a new GREEN input [7].

RESULTS AND DISCUSSION:

Though the sun proves to be a nice symbol of god's creation, it has a great disadvantage of emitting large quantities of harmful radiations from its surface preventing communication systems in space from performing properly and efficiently. These radiations not only affect satellites, but also affect space crafts, space stations and the scientists at the space stations.

In order to protect such possible damage to the communication systems, it is necessary to use materials with special properties that will be highly resistant to radiation, while keeping the size and weight of the communication systems as small as possible.

CONCLUSIONS:

From our study we arrived at the following conclusions:

- 1) Use of grit-blasted tungsten provides protection from high amount of heat for solar cells.
- 2) Use of carbon nanotubes (CNTs) provides protection against radiations that would otherwise penetrate the complicated electronic devices inside the satellites and other broadcasting stations in space.
- 3) CNT made solar cells are relatively small in size and lighter; therefore, they incur very low transportation costs while giving the maximum protection from flares for sophisticated components in space communication systems.
- 4) Further research would suggest that the use of CNTs would help the satellite

move around its orbit much more efficiently due to its weight being reduced to half its current weight.

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