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ON A POSSIBILITY FOR COMMUNICATION AND COMPUTING DEVICES EMI SHIELDING

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Abstract. *Recently many international terrorist groups can actively plan coordinated attacks against both military and space computer and telecommunication systems and civilian critical infrastructures (such as Supervisory Control and Data Acquisition Systems), using high level electromagnetic field techniques. Because the electromagnetic interference (EMI) shielding activities play the major role for the prevention of the damages, disrupt equipment operations, change processing control, or corrupt stored data. High energy electromagnetic fields with a large frequency range, different duration and intensity can overload circuit boards, transistors, and other electronics, as well as they can erase electronic memory, upset software, or permanently disable all electronic components.*

Defense and Security Sector leaders plan different strategies in the three directions: ONP (Open Network Provision), Satellite Telecommunication (ST) and Mobile Telecommunication Systems (MTS). All of these directions include the protection against non-authorized accesses to the data bases and voice transmissions, which can implement via a interception of own frequencies as well as the protection against directed electromagnetic hazardous flows.

The present paper reports some results concerning scientific investigations, testing and industrial incorporation of a easy accessible, inexpensive, high efficiently and reliable method for EMI shielding – electrochemical deposition of amorphous metal alloys layers onto both outer surfaces of the products boxes and surfaces of the inner interposed modules, independently of their materials - plastics, aluminum alloys or ferrous metals. These advantages allow the method to be high competitive, compared to the other methods, and draw its future development and multiplication.

I. INTRODUCTION

Recently the conventional weapons have a shorter possible range. The international terrorism in the 21st century is the main threaten war [1].

A project developed under contract with US DoD reports that computer attacks and cyberterrorism intended to harm the economy, security and defense all over the world [2]

Based on the statements of the NATO EUCOMM leaders, defense and security sector plans different strategies in the three directions: ONP (Open Network Provision), Satellite Telecommunication (ST) and Mobile Telecommunication Systems (MTS). The main role in these strategies plays the EMI shielding [3].

The *Johns Hopkins* University Applied Physics Laboratory develops many applied projects concerning EMI shielding of the military, space and civilian infrastructure systems. Based on a statement of Mr. Gary Smith, the Laboratory Director, before the Subcommittee on Military Research and Development, about 80% of the funding comes from sponsors within the Department of Defence and about 15% from the National

Aeronautics and Space Administration. The rest comes from various government departments and agencies [4]. More attention is emphasized to the high energy electromagnetic pulse (so called EMP). Some systems are vulnerable to the distortion under the electric field of 50 KV/m, with a rise time on the order of 10-200 ns and from a distance of 10 m. The EMP effects both in the military and civilian infrastructure. An electromagnetic field interacts with metallic conductors by inducing currents to flow through them. A television antenna, for example, is a collection of metal conductors arranged to facilitate the induced current flow in the frequency bands allocated for television broadcasting and to transfer the signal to the receiver. Other conducting structures such as aircraft, ships, automobiles, railroad tracks, power lines, and communication lines connected to ground facilities also effectively serve as receiving antennas for EMP coupling. If the resulting induced currents and voltages - which can be large - are allowed to interact with sensitive electronic circuits and components, they can induce an upset in digital logic circuits or cause damage to the components themselves. The collected EMP energy itself can cause malfunction or device failure directly; or it can trigger the system's internal power sources in unintended ways, causing damage by the power sources within the system itself.

ALLIED SIGNAL CO applies for the first time METGLASS-2826 as a magnetic shield named METSHIELD. It consists from a knitting stitch of amorphous strips implanting into fabrics which are coated with plastics. The shielding ability of such four-layers shield (thickness 180 μm, mass 700 g/m) is in the range of 30-40 dB, if the intensity of the electromagnetic field is about 6 Oe [5, 6].

As is shown [7], the shielding efficiency of the closed boxes against the magnetic component of the field is 35-40 и 27-30 dB, applying the field intensity 0.2 и 2 Oe respectively. Under the same conditions, the shielding efficiency against the electric component of the field in the range of frequency from 10 kHz to 18 GHz is 50-80 dB.

The US SHIPLEY CO has developed a high level technology for EMI shielding named OMNISHIELD [8]. It includes several processes for both autocatalytic electroless and electrochemical depositions on the PCB for military and space electronics.

The US AF Construction Engineering Research Laboratory (CERL) with Technical Working Group of the Joint Committee on Tactical Shelters has developed a wide range of materials and technologies applied to several electronic systems [9]. There are very perspective metal high dispersive powders for fillers in the varnishing materials, impregnating the textiles or in the plastics for boxes. By this way impregnating flexible cases and wallpapers with electromagnetic shielding properties can be produced and they are applied to the protection of high dimension electronic systems, including mobile and fixed radar stations, command terminals, computing centers etc.

Independently of the emphasizing upon the expensive systems, many others details and components are subjected to the shielding efforts, such as displays, cables, connectors and precious solder points for Harrier [10].

A new field of activities offers the optic fiber electronics using in the Army, Air Force, Navy and Space for high velocity and protected transmittance of audio-, video- and digital data bases [11-14].

II. EXPERIMENTAL

Our investigations [16, 17], compared to the SHIPLEY [8], which uses high electrical conductive metal layers for the shielding only of the electrical component of the pulse fields, are directed to the application of soft magnetic amorphous electrodeposits. Indeed, soft magnetic properties can be reached by thermomagnetic annealing, but it is possible only for ferrous materials. This method is not applicable for aluminum alloys and plastics of ABS–copolymers, used for boxes for electronic articles. A unique method in these cases is only the electrochemical deposition of multilayer, multicomponent protective system from plated coatings. The behavior combination: amorphous structure, phase composition and multilayer metal coating leads to the result that the shielding effect is reached on the base of laws of multiple inner diffusion scattering and reflectance of the electromagnetic pulse. By this reason the protective system thickness is not limiting factor for the shielding efficiency. By the other words, the attenuation flow gradient under certain electromagnetic field conditions (the pulse intensity and duration) is not controlled from layer thickness, but from the structure and composition of the layers.

The experiments were carried out using a wide range of samples, both models (self-made boxes from different materials with suitable dimensions) and real products (PC with different processor frequency, HF-, VHF- and SHF transmitters, voltage- and interface cables etc., subjected to the inner or outer electromagnetic pulses, defined by power energy, intensity, frequency range and duration parameters. In the all cases the pulse attenuation from the shielded sample was compared to the unshielded one as well as the value of the environment space was measured and subtracted from the sample value. The experimental conditions for the electrodeposition of the different layers of the protected system are reported in the former works [16, 17, 19-22]. The measurement methodic was adapted to the requirements of the US military standard MIL-STD-461E/1999 [15].

The test equipment involved:

- Measurement receivers
- Current probes
- Signal generator
- Data recording device
- Oscilloscope
- Resistor (R)
- LISNs (Line Impedance Stabilization Network)

The results are compared to the requirements of the US Federal Communication Commission (FCC).

The present paper reports the results obtained from the telephone set Type TTT-100, ptotected with multilayer, multicomponent system of electroplated amorphous metal alloys coatings, produced from “Telephone and Telegraph Technique” PLC, Sofia, Bulgaria. The total structure of the protected systems comprises four layers, the last one consisting of a four component amorphous alloy Fe-Ni-Co-P. The overall thickness is about 40-45 μm (on one side) and all parts of the telephone set (keys included) are plated on both sides.

The attenuation as a measure unit for the EMI shielding ability was measured within a broad frequency band (10 kHz - 1000 Mhz).

III. RESULTS AND DISCUSSION

The former our works [16, 17, 19-22] results, obtained from the scientific investigations of the models and real samples, are the base for the invention of the technology for protected multilayer shielding system. The technology is adopted in the serial production of the “Telephone and Telegraph Technique” PLC, Sofia, Bulgaria, which produces an advanced telephone set Type TTT-100 for military and security application.

The advanced telephone set covers all the existing requirements for functionality and physico-mechanical characteristics and reliability within the -10 to +50^{o}C range at ambient relative humidity up to 95 %, but many new requirements are added concerning the electromagnetic shielding properties due to the electrodeposited protected multilayer system and its consisting layers, such as physico-mechanical properties of the layers (adhesion to the substrate and between the layers, hardness, wear resistance, breaking resistance etc.).

Other reliability parameters are:
- life span during usage - more than 20 000 hours operation
- shelf life - more than 10 years storage in closed warehouses without heating

The telephone set was shown on the Int. Conf. Defence Research and Technologies "Modernising the Forces - Cornerstone of the Bulgarian Way to NATO", Telecomm Exhibition Hall, Plovdiv, Bulgaria, May-June 2002 [18]. It obtains very high performance and quality evaluations from Israeli and Romanian experts who have severe requirements to the protection from non-authorized accesses to the data bases and voice transmissions, as well as to the protection against directed hazardous electromagnetic pulses.

The main technical characteristics (TTC) are summarized in the Table:

No	Parameter	Requirement	Measured
1.	Shielding Ability	from 30 to 55 dB	60÷70 dB
2.	Adhesion to the substrate	700 MPa	in conformance
3.	Hardness (of the coating)	600 MPa	in conformance
4.	Appearance (of the coating)	smooth, compact, dark grey metallic	in conformance
5.	Sanitary standard	Harmless for human respiratory organs, skins and eyes	in conformance
6.	Environment-friendly standard	Harmless after sell-by date	in conformance
7.	Maintainability and recycling	Repairability of the random damage surfaces, overhaul repairing after full stripping of the electrodeposits	in conformance

The experimental results of attenuation measurements are shown in Figure 1 and they are compared to the FCC regulations rules. It can be concluded, that the electromagnetic protection of the telephone set TTT-100 is higher than maximum allowable emissions demanded as limits for all the classes of equipments, apparatus and articles:

- Surface Ships
- Submarines
- Aircraft, Army, Including Flight Line
- Aircraft, Navy
- Aircraft, Air Force
- Space Systems, Including Launch
- Vehicles
- Ground, Army
- Ground, Navy
- Ground, Air Force

The original plot of the FCC is step-like, depending of the different frequency bands (up to 250 MHz and from 250 to above 1 GHz). Our results exceed the FCC values in the all frequency bands.

Figure 2 shows a photo of the telephone set TTT-100.

The last four-component amorphous layer allows to be covered using varnishes of all colors, including camouflageability one.

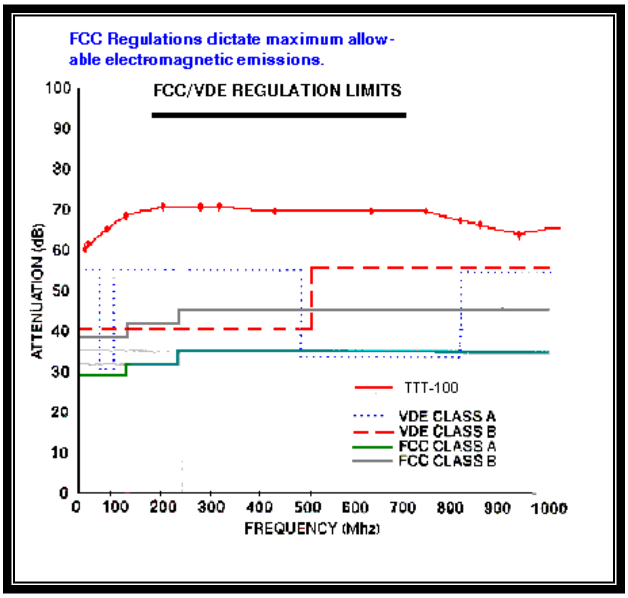

Figure. 1. The FCC rules compared to the emission of the TTT-100

Figure 2. Photo of the advanced type of TTT-100

IV. CONCLUSION

Scientific research and inventorship activities of the leading Institutes and firm research centers give different possibilities of the technical decisions applying to the protection of the computing and telecomm devices, apparatus and articles against electromagnetic interferences. The offered in the present paper possibility based on a protected system, consists of multilayer, multicomponent electroplated amorphous metal alloys coatings, is a easy accessible for industrial incorporation, inexpensive, high efficiently and reliable technology. It is high competitive, compared to the other technologies, based on expensive methods, equipments and apparatus such as laser glassing of the metal surfaces, thermomagnetic annealing, vacuum sputtering etc. In the case of the plastic materials for boxes the present technology is unique.

These advantages draw the future development and multiplication of the technology. Very perspective are the electrodeposited layers both amorphous and nanocrystalline, including new phases, based on V, W etc. metal components, as well as using not only P, but B, C and other additives. It can be to reach by way of the improvement and perfection of the scientific investigations – new processes for electrocrystallization and electrodeposition of the metal alloys, new equipments for modern observation and testing. There are many human scientific potential and industrial skilled workers in Bulgaria. They need moral and finance support.

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REFERENCES

1. Statement of Dr. Lowell Wood 1997 Congressional Hearings Special Weapons Nuclear, Chemical, Biological and Missile
2. Shartow, W., IDG Rep.,1991
3. Boniet, E., IDG Rep.,1991

4. Statement of Dr. GARY L. SMITH DIRECTOR THE JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY 1997 Congressional Hearings Special Weapons Nuclear, Chemical, Biological and Missile
5. ALLIED CHEMICAL METGLASS Products Brochure: METSHIELD Fabric for Magnetic Shielding, 1977, Дисмюкс, Дж. Р., Селлерс, Г. Дж., Быстрозакал.мет.,пер.с англ., 343-9, М."Металлургия", 1983.
6. Huang,D.R. et al, J.Appl.Phys.,57(8,Rt.2A),3517-9,1985
7. SHIPLEY EUROPE LTD PROSPECTS,1988
8. Electromagnetic (EM) Shielding Materials-Gaskets and Seals, The Construction Engineering Research Laboratory (CERL), 2003, US Army Corps of Engineers, Engineer R&D Center,
9. Electromagnetic Interference In High Reliability Electrical Interconnect Systems Glenair Inc, Corporate Headquarters (USA), Проспектни материали 2004
10. Fiber Optics in NAVFAC Operations, Military Engineer,75 (490),524,1983.
11. Fiber Optics: Fiber Optics Sensors,Int.Def.Rev.,17(2),153, Optical Fiber in Aviation,Avionics,11(3),12-4,1987
12. Fiber Optics: Communications of the Future, Military Tech., 8(6),31-40,1984
13. Laser-induced Conversion of Sputter-deposited amorphous silicon, Aviation Week & Space Tech.,116(14),63,1982;Def.Electron.
14. Luft, W.,Conf.Rec.IEEE Photovoltaic Spec.Conf.10th,Meeting Date 1973,174-9
15. MIL-STD-461E/1999 DEPARTMENT OF DEFENSE INTERFACE STANDARD REQUIREMENTS FOR THE CONTROL OF ELECTROMAGNETIC INTERFERENCE CHARACTERISTICS OF SUBSYSTEMS AND EQUIPMENT
16. Върху някои аспекти на електролитното отлагане на аморфни сплави, Вучков, Л., Юбилейна научна сесия на ВВОВУ "В.Левски", В.Търново, 27-28 май 1993 г., Научн. тр., кн. N 25, секц. “Химия и физика”, стр. 97
17. Върху някои свойства на аморфните метали с оглед затихването на електромагнитни излъчвания, Л. Д. Вучков, Юбилейна научна сесия на ВВОВУ "В.Левски", посветена на 100-годишнината от създаване на радиото, В.Търново, 15-16 юни 1995 г.
18. Telephone Set type "TTT-100" with secured Protection against Electromagnetic Interference, Vuchkov, L., Raichevski, G., Stantchev, O., Int. Conf. Defence Research and Technologies "Modernizing the Forces - Cornerstone of the Bulgarian Way to NATO", Telecomm Exhibition Hall, Plovdiv, Bulgaria, May-June 2002
19. Protection of Communication and computerized Equipment against Electromagnetic Interference multi-layer galvanic Coatings, V. Bachvarov, Vuchkov, L., Raichevski, G., Appl. Sci. Symp. "New Industrial Materials", University of Sofia "St. Kl. Ochridski", Faculty of Chemistry, May 30, 2002, p. 18
20. Electrochemical Corrosion Behavior of Amorphous and Nanocrystalline Electroplated Alloy Layers of the Metals of the Iron-group, V. Bachvarov, Tz. Vassilev, Raichevski, G., Vuchkov, L., Fourth Workshop on Nanoscience & Nanotechnology, Poster Sec. 4.04 "Submicron Inhomogenities and Phases in bulk Materials, Nanocomposites, Oct., 17-19, 2002, Sofia, Bulgaria
21. Electrochemical Corrosion Behaviour of Amorphous and Nanocrystalline Electroplated Layers of Iron, Nickel and Cobalt Alloys, Bachvarov, V., Vassilev, Ts., Raichevski, G., Vuchkov, L., Nanoscience & Nanotechnology, 3, pp. 145-147, Heron Press, Sofia, 2003
22. Communication and Computer Techniques Protection against Electromagnetic Interference using multi-layer galvanic Coatings, V. Bachvarov, G. Raichevski, L. Vuchkov, Fourth Int. Congress "Mechanical Engineering Technologies", Sec. III "Mat. Sci., Heat Treat., Thermo-chem. Chem. Treat.", Sci. Proc. XI, Vol. 5/73, pp. 147-149, Sept. 2004