Comparison of 3D printing and galvanic coating of gold in printing circuit board production

Zoran Karastojković[1], Radiša Perić[2], Aleksandar Bugarinović[3], Milan Miladinov[4], Višeslava Rajković[5]

***Abstract*— It became a practice that in printing circuit board (PCB) production is used gold, as an exelent conductor of electricity and highly corrosion resistant (noble) metal. Gold always was an expensive metal, but in great game of electronic decices this metal must be used as a best solution, no matter for the high price. Many processes of gold deposition are available in PCB production, one of them is gold deposition by using electrolytic (or galvanic) process. However, a wide versatility of electrolytic methods were developed for production of circuit boards. In meanwile is established the one more method for curcuit production which is based on so called 3D printing.**

Between those processes existing some differencies, which need furter explanations for better understanding the PCB production, it means the reasons for choosing the proper method.

Key words: Printing circuit board, galvanic coating, 3D printing

1. INTRODUCTION

It could be said that production of PCB on galvanic (electrolytic) manner belogs to two dimension, shorter 2D. When becames clear that production of PCB by 3D printing may be cheaper than traditionally manufactured boards, this new technology has attracted a great attention. Further, 3D technology allows more complex design.

The PCBs consist from different components, depending to the final purpose of this *equipment*. So, resistors could be considered s one of the crucial component in a PCB design. But there are other electronic devices as: transistors, diodes, capacitors, inductors, sensors, etc, Fig. 1. In describing of a PCB is noticed that such board in geometric sence should be flat, other variety of informations about the functionality of this device are available in wide literature sources. In this paper the matter of consideration will be a flatness of gold traces (as a conductive layer), obtained either by galvanic or 3D printing methods.

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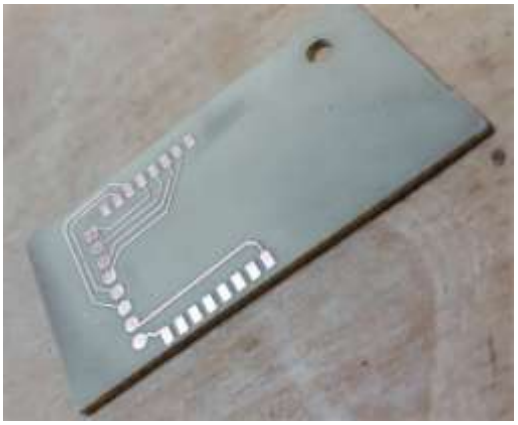

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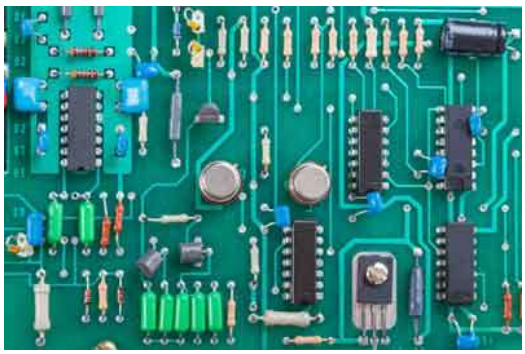

b)

Fig. 1, Two examples in designing of printing circuit board (PCB): a) monolayer and b) multilayer design

2. SHORTLY ABOUT THE STRUCTURE OF LAYERS

A PCB may contains just one conductive layer, Fig. 1a), or multilayers, Fig. 1b): monolayer is pretty restrictive in function abilities while design with multilayers offers a wide versatilities in making interconnections, etc. So, in designing and terminology of multilayers may be present: the top layer, an internal layer and the bottom layer, above the substrate material. Frequently an insulating layer must be present - if is needed. It must be underline that this vocabular (top, internal or bottom layer) may not be typical scientific but rather engineering terminology, particulary during fabrication of PCB devices. Multilayer, indeed, has an influence on the thickness of such boards. The four layer frequently is recommended, of course when it is possible. It is desired that the top layer is at the same time a corrosion resistant and with excelent conductive properties, as gold does, Fig. 2.

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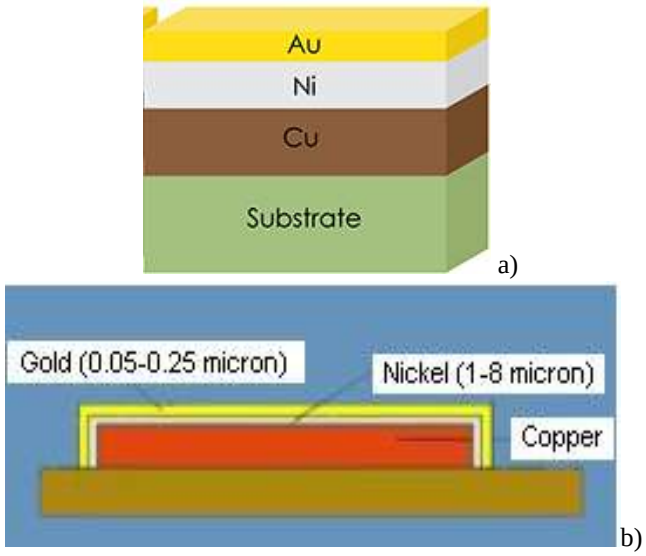


Fig. 2. Composition a) and thicknesses distributions b) at one three-layer structure over substrate material

Each layer has a different function. The multilayers are used for improving the PCB performance. From many reasons (structure, hardness, price etc.) the nickel coating also may be used, as indicated in Fig. 2. As the top layer could be chosen a golded layer from one more reason, previously not mentioned, it is a soldering ability with other components from PCB. The golden layer, also called a trace, posses a pretty good soldering ability. Other facilities of (multi)layers are the subject of specialities in designing of PCB, here is the matter on wich way the deposition of gold layer may be provided.

3. ELECTROLYTIC COATING OF PCB

Electrolytic (galvanic) deposition is the well known technology in surface finishing purposes, almost as a method for imrpoving the anticorrosion properties and/or for decorative properties, but also as one of the oldest method in production of traces onto PCB. Next advantage of electrolytic deposition of metals is in possibility to attain a layer over different materials, almost metallic materials but this is not obvious. Principles and technology of such kind of fabrication are well known and applied all over the world. The pure gold could be electrodeposited and than this js known as a “soft gold”. Another tape of gold deposition is provided through an alloy (usuallly with nickel, cobalt or other metals in amount less than 0,2%) when is needed greater hardness, especially at surfaces where the force and than a friction is appeared, so such kind of golden layer is named “hard gold”. The possibilities of mixing the chemical compounds for achieving the proper electrolyte(s) also are pretty well established.

Many metals are available for electrolytic deposition, but not all of them. One of the important advantage in galvanic electrodeposition of golden layer is the possibility to attain thickness of 1μm, even less. This fact has shown a great importance in production of narrow and/or thin circuit boards, every where applied (in computers, mobile phones, TV apparatus, etc.). One example of possible thickness distribution of different layers is shown in Fig. 2b). It is found that the gold layer thickness has shown an influence on the porosity: if thickness is less about 0,40μm than the porosity rapidly increases, further when the thickness of this layer is about 0,75μm than the porosity will be markably low. No doubt that porosity or other imperfestions at the substrate material will produce a kind of porous surface at golden layer, even after the galvanic process is correctly applied.

During a longterm heating-up in service periode some electrochemical migrations are possible, which could resulting in metal dendrites formation at the layer between the two adjacent electronic components (electrodes).

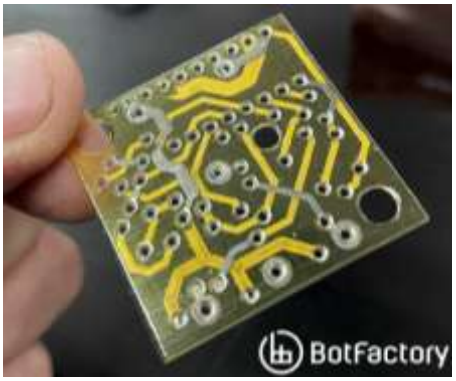
It should be noticed that the using of versatility of electrolites may produce a harmfull waste components.

4. 3D PRINTING OF PCB

In last decades the 3D printing as a production method becomes very attractive, especially in modeling and similar demands. In such cases the 3D method is a pretty fast and cost-less method. At many advertisements might be found just a perfect appearance, Fig. 3a). But, not every 3D modeling obviously should be successful, as could be see from Fig. 3b), where the non-uniform thickness is evident.

The printing material, here it is gold metal, should be melted during deposition and this fact represents some kind of risk when the layer is formed on plastic material, because plastic material posses a pretty power melting temperature than gold. The producing of small amount of a kind of gold alloy in the form of wire is technically possible but may be an expensive job. The case from Fig. 3b) is not desired anyway, because the flatness will be destroyed, also with markably increasing the roughness (with unequal surface topography) and a large amount of expencive gold will be unusually spent. At the contemporary level of technics the smaller thicknesses on PCB could be achieved by using a galvanic method of deposition

It seems resonably an expecting that 3D technology does not produce some harmfull components, however it is an important benefit.



a)

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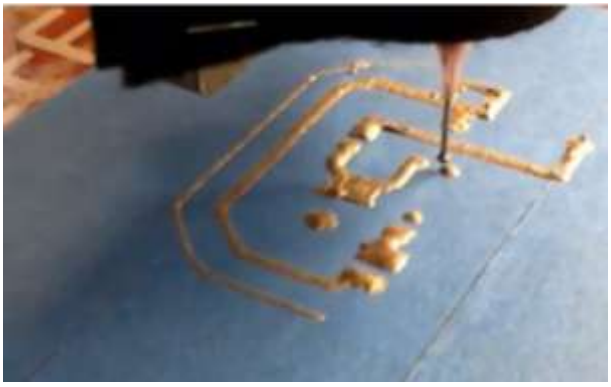
b)

Fig. 3. Results after applying the 3D printing method with using the golden wire in production of one circuit board:
a) correct and b) incorect

CONCLUSION

Flat and thin surface are needed at every production method. The golded traces are wellcome in PCB from one more reason – easy soldering with other components. In galvanic (electro-deposition) is possible to attain a golden layer in thickness of 1μm, even less, but this demand still is impossible if 3D printing method is used. Surface roughness after galvanic deposition is pretty satisfactory while after applying 3D printing the roughnes is greater.

The producing of chemicals for electrolytic deposition of variety metals in the form of (inexpensive) salts or luquids now are present in industry in a great scale and could be supplied relatively eaisy, while the golden wire made from particular alloy (as mentioned with cobalt or similar) in a small amount for 3D printing still is an expensive job.

Thicknesses obtained by using 3D printing fabrication eventualy may reach values above 0,1mm, what is much greater in comparison to galvanic method of deposition. So, the 3D printing method in production of printed circuits is available only at such circuits when the thickness is greater in comparison to galvanic method of deposition.

But, the dissadvanage of galvanic tehnology is in production of variety harmful components, as a waste material, while 3D technology does not.

References

[1] J. Kusinski, S. Kac, A. Kopia, et all.: Laser modification of the materials surface layer – a review paper, Bull. of the Polish akademy of sciences, Technical sciences, 60/2012/4, p. 711-728.
[2] J. Sundqvist: Aspects of heat flow in laser materials processing, 2018, Doctoral Thesis, Lulea University of Technology.
[3] N. Rykalin, A. Uglov, I. Zuev, A. Kokora: Laser and electron beam material processing, Handbook, Moscow 1988, MIR Publ, p. 277-353.
[4] https://www.sharrettsplating.com/blog/benefits-of-electroplating-3d-prints/
[5] Z. Karastojković: Površinska zaštita metala, in Serbian, Visoka tehnička škola strukovnih studija, Novi Beograd 2016, p.150-162.
[6] Z. Karastojković, P. Karastojković, S. Polić, Protective and decorative role of golden foils on sacral objects, Proceedings of XXI YuCorr, Meeting point of the science and practice in the fields of corrosion, materials and Environmental protection, September 17-20, 2019, Tara Mountain, Serbia, Serbian society of corrosion and materials protection, p. 21 – 30.
[7] З. Карастојковић, С. Полић, П. Карастојковић, Методологија и дизајн у производњи православних златних крстова / Methodology and design in production of ortodox golden crosses, Зборник апстраката, Друга национална конференција Методолошка истраживања у херитологији и новим технологијама, Друштво за етичност и вредновање у култури и науци и Централни институт за конзервацију, Београд, 2020, стр. 74-80.
[8] N. Bajič. Z. Karastojković: Savremeni postupci navarivanja, IRC IHIS Technoexperts 2016, 11080 Zemun, Batajnički put 23, Srbija, str. 200-203.

Apstrakt

Postala je praksa da se u proizvodnji štampanih koma (PCB) koristi zlato, kao izvanredan provodnik struje i jako koroziono postojan (plemenit) metal. Zlato je oduvek skup metal, ali u ogromnom broju elektronske opreme ovaj metal se mora upotrebiti kao najbolji materija,. bez obzira na visoku cenu. Brojni procesi taloženja zlata su primenljivi u izradi PCB, jedan od postupaka je elektrolitičko (ili galvansko) taloženje. Dakako, veliki broj elektrolitičkih metoda je razvijen za proizvodnju štampanih kola. U međuvremenu je razvijena još jedna metoda u proizvodnji štampanih kola, koja je zasnovana na tzv. štampi.

Između ovih procesa postoje izvesne razlike koje zahtevaju dalja razjašnjenja za bolje razumevanje proizvodnje štampanih kola, to znači razloge za izbor odgovarajuće metode.

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