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ECOSOLDER

Romania – Republic of Serbia
IPA Cross-border Cooperation Programme

Project: Promoting new ecologic filler alloys for soldering, based on the non-ferrous ore of the Romanian-Serbian cross-border area

Project Reference: MIS ETC Code 1409

WORKSHOP 2 at ISIM 26th of September 2014

"Ecologic Alloys for Soldering and Brazing. Brazing and Soldering Procedures"

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"Experiments on soldering printed circuit boards, with a new ecologic filler alloy"

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CONTENTS

Experiments for following processes have been carried out:

1. Electric soldering

2. Laser soldering

Experiments with new alloys for soldering and brazing, produced by MMI Bor, are also presented .

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1. Electric Soldering. Technical requirements

- *Experiments are described, of electric bit soldering of the components on a printed circuit board with the sizes 100 mm x 25 mm of a voltage monitoring device for car accumulators.*
- *This is a classical process aimed to special application of a new elaborated filler alloy for soldering.*
- *The applied process is soldering based on electrical heating [1].*
- *Verification of both its technological and ecological characteristics [2] are intended.*
- *The filler alloy is elaborated in the frame of the Ecosolder project, by the Partner, the Mining and Metallurgy Institute of Bor, Serbia.*

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Base metal and New solder

- ***Base metal***

Table .1. Chemical composition % of grade Cu-ETP (CW004A), EN 13599 Cu including Ag < 0.015%; O < 0.06% is permitted				
Cu	Pb	O	Bi	Others
min 99.9	max 0.005	max 0.04	max 0.0005	total 0.03

- ***Filler alloy. New solder developed by MMI Bor***

Table .2 Chemical composition (%) of the filler alloy S-Sn90In7Ag3													
Fe	Ni	Al	Cu	As	Pb	Zn	Ag	Sb	Bi	Cd	Au	In	Sn
max 0.02	max 0.01	max 0.001	max. 0.2	max 0.03	max 0.1	max 0.001	2.8 – 3.2	max 0.1	max 0.01	max 0.002	max 0.05	Max 6.5 -7.0	Remain-der

- ***Flux: colophon***

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Common ecological solders

- ***Common ecological solder***

Table 3 Chemical composition % of grade S-Sn97Cu3 (402), EN ISO 9453 [4,5,6]													
Fe	Ni	Al	Cu	As	Pb	Zn	Ag	Sb	Bi	Cd	Au	In	Sn
max 0.02	max 0.01	0.001	2.5 - 3.5	max 0.03	max 0.1	max 0.001	max 0.1	max 0.001	max 0.1	max 0.002	max 0.05	max 0.1	Re-main-der

- ***Ecological solder for printed circuit boards PCB***

Table 4 Chemical composition % of alloy S-Sn96Ag3Cu1 (711), EN ISO 9453 [4,5,6]													
Fe	Ni	Al	Cu	As	Pb	Zn	Ag	Sb	Bi	Cd	Au	In	Sn
max 0.02	max 0.01	max 0.001	0.3 – 0.7	max 0.03	max 0.1	max 0.001	2.8 – 3.2	max 0.1	max 0.01	max 0.002	max 0.05	max 0.1	Re-main-der

- ***Flux: colophon***

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Soldering devices

- ***Soldering iron (copper bit) rated at 100 W power is used. The rated duty factor ratio of the electric soldering copper bit is 20%, related to the duration of one minute of the duty cycle. This means 12 seconds on power, related to 48 seconds pause.***

- ***The temperature-controlled soldering copper bit has a supply station, rated 80 W, at 24V, with a pre-settable temperature range of 150-400ºC.***

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Fig.1. Top side of the printed circuit board and the filler alloy

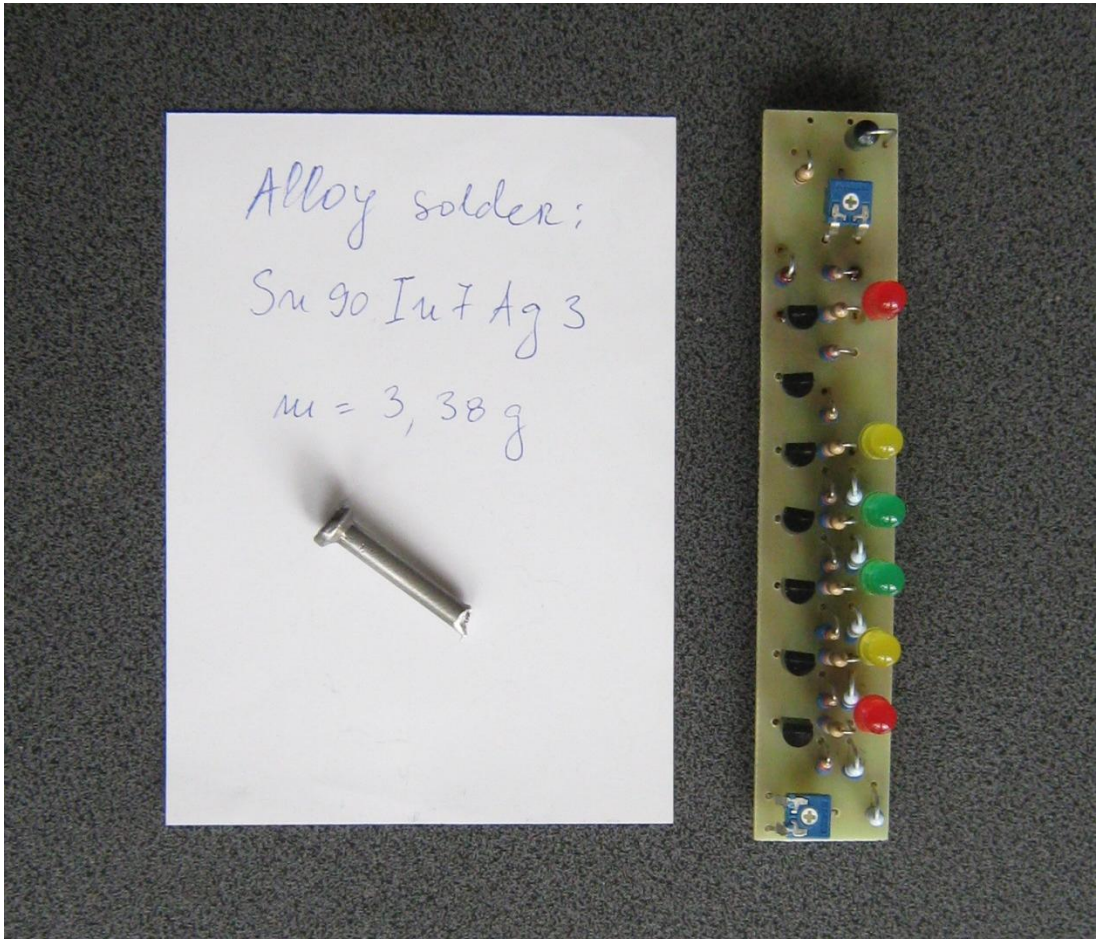

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Fig.2. Melting a drop of the filler alloy, onto the tip of the copper bit

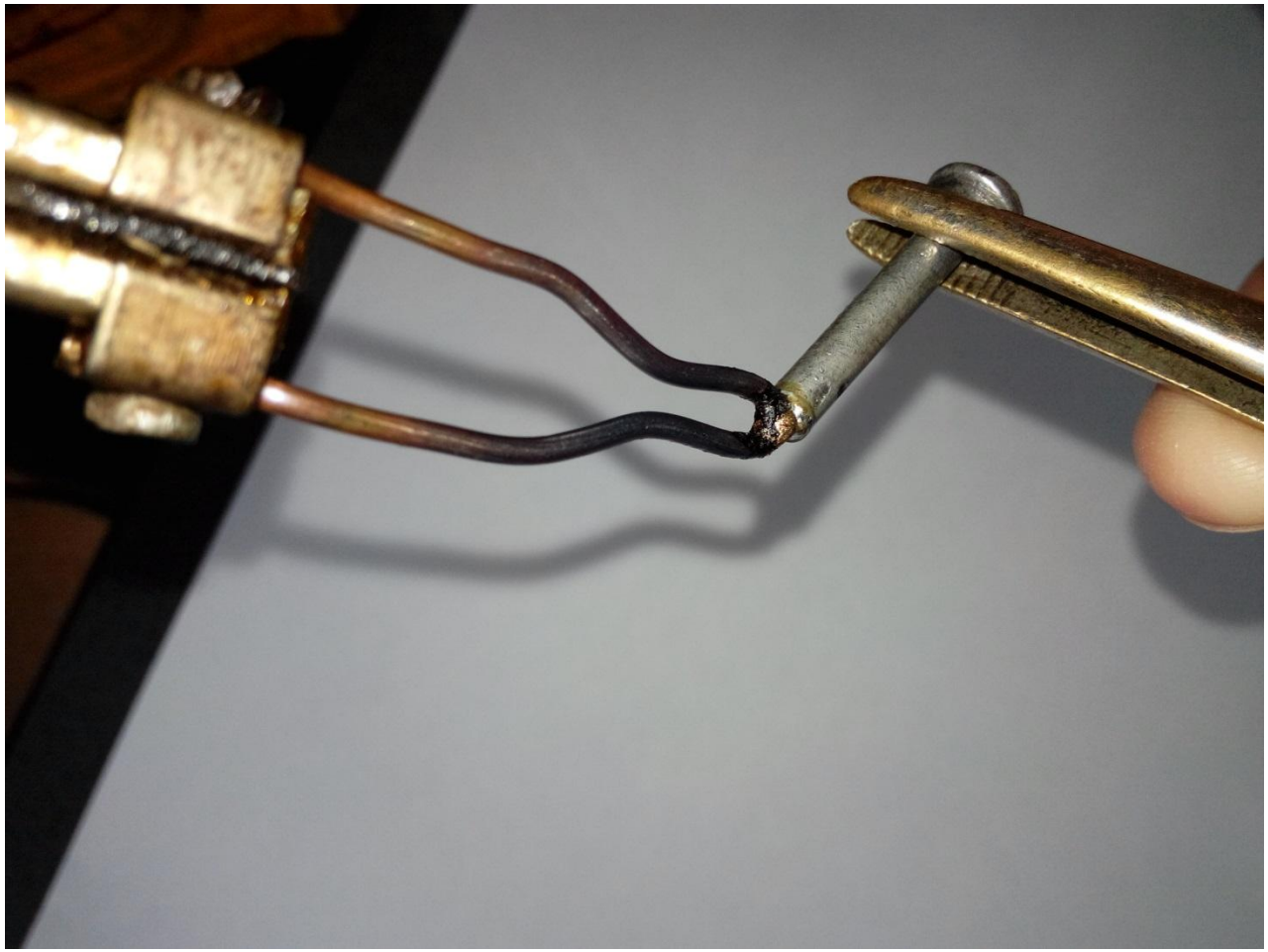

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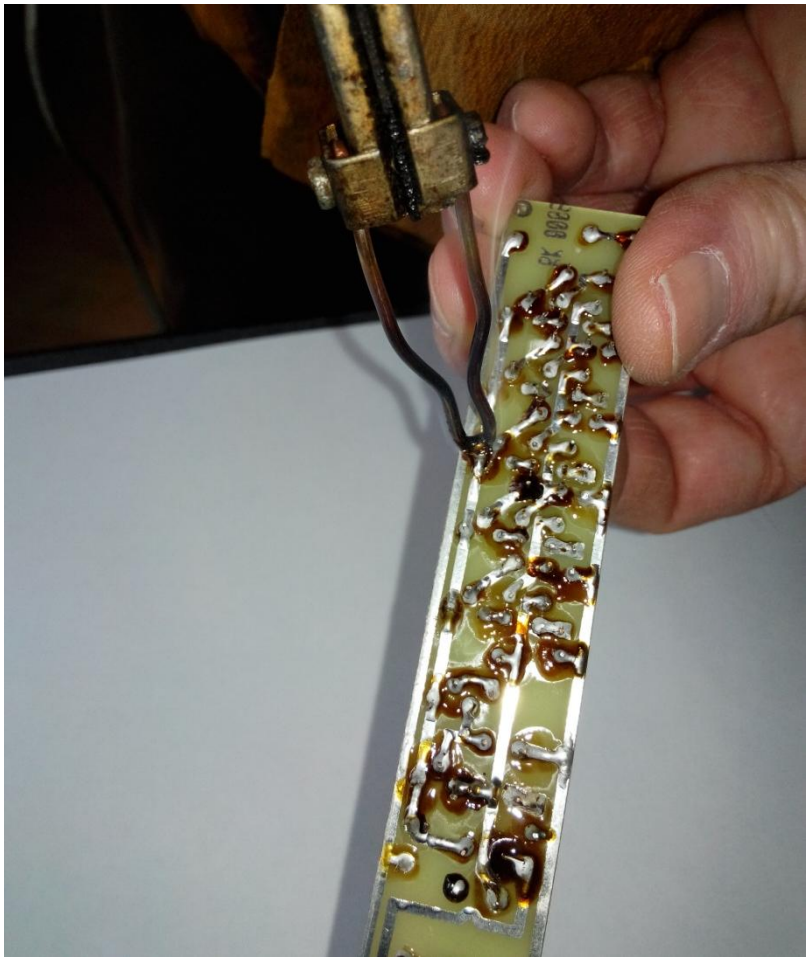
Fig.3. Better application of a solder drop on the pad of an electronic component terminal



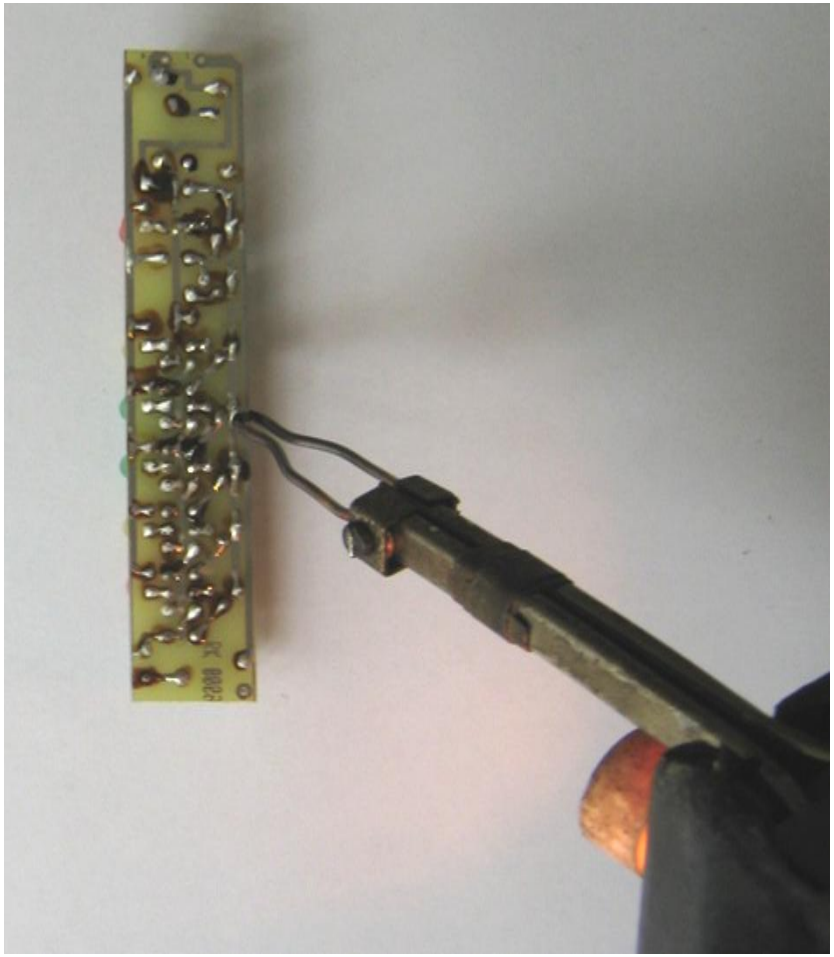


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Fig.4 Soldering operation with a temperature-controlled iron

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Fig.5 Bottom side with the soldered joints of the PCB

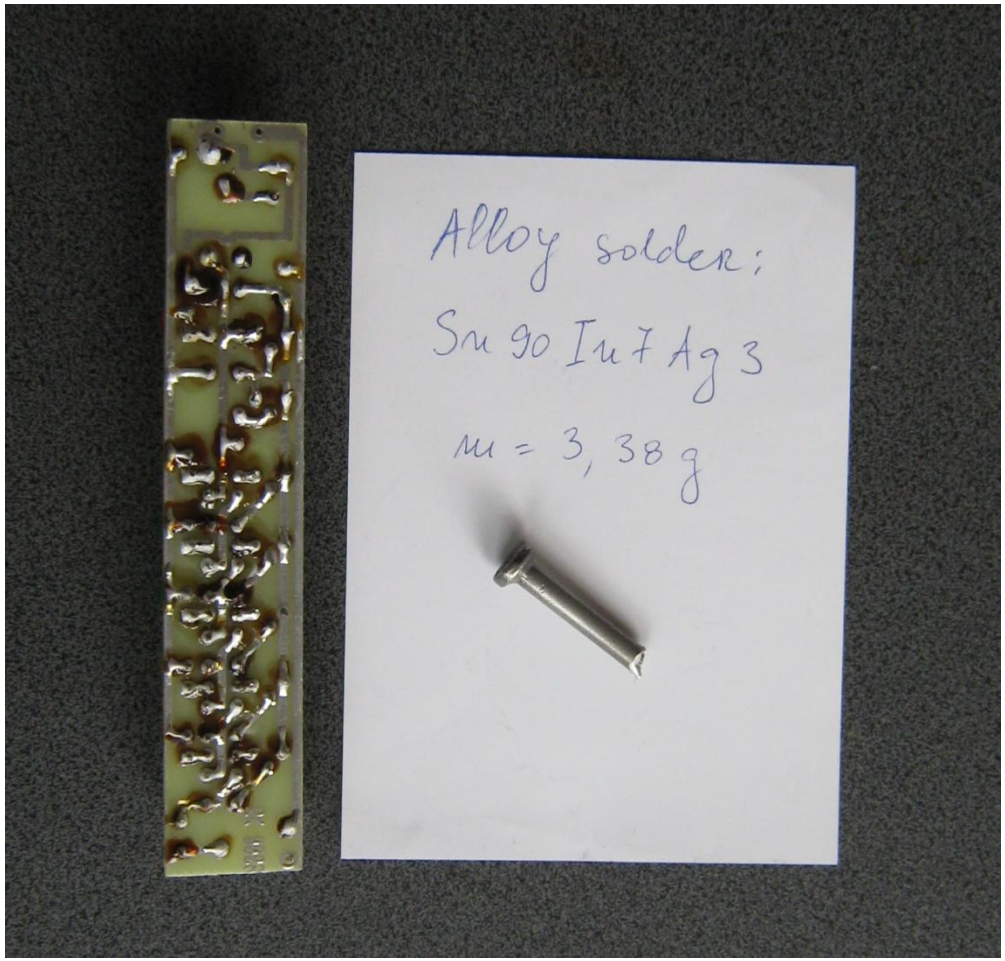

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Fig.6. Additional soldering tests on a PCB of an experimental supply source

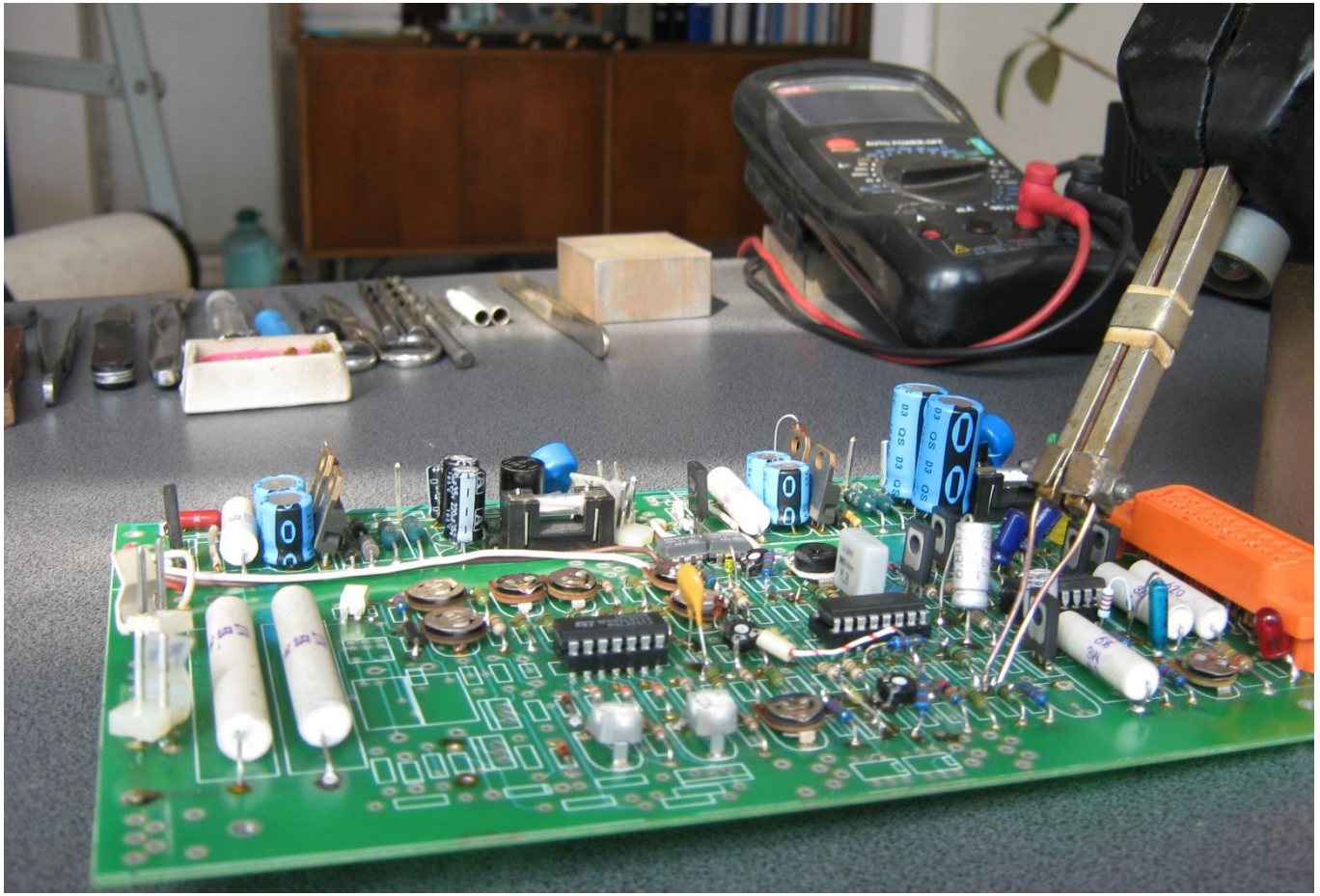

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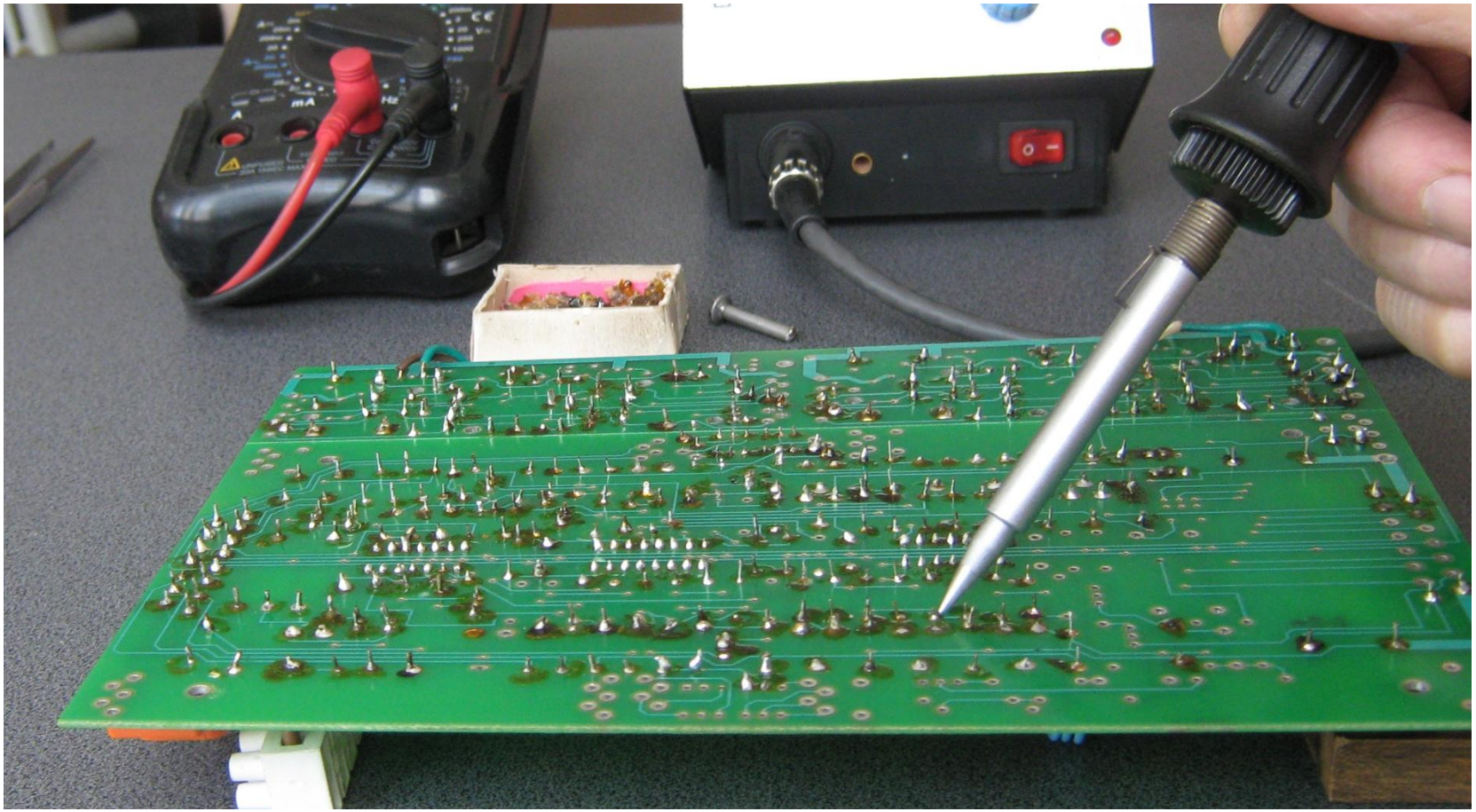
Fig.7. Soldering on the bottom side of the PCB of an experimental supply source



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Ecological properties and work safety

- Due to its chemical composition, the soldering alloy S-Sn90In7Ag3 does not exhale any hazardous substances neither for the operating persons, nor for the environment.
- The colophon, used as flux in the soldering operation, may also get overheated and decompose in some volatile substances.
- The most efficient work safety measure for the occupational health is the local exhaust ventilation. In order to assure also the preservation of the environment, the toxic substances of the exhausted gases and fumes should be neutralized and filtered. Then, the filters must be treated in special installations, by authorized persons. The remains of the treated filters must be disposed of only in special locations for this purpose.

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Visual examination

- ***Visual examination, according to EN 12799:2000 [7], of the soldered joints was applied. The soldered joints have adequate appearance. They are well shaped, symmetrical around each terminal and they cover the holes of the board. There is no leakage of molten alloy through gaps of the holes, to the opposite side of the board. In the deposited drops there are no defects, like: cracks, porosity, lack of metal, lack of fusion, lack of adherence, additional metal, spatter, burnt cooper foil or burnt isolating material, etc.***
- ***Tear-down test is recommended to verify the adhesion of he soldered joints to he copper pads of the electronic components terminals, according to the fabrication norm of the product.***

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2. Laser soldering
Laser equipment employed

The soldering tests were executed with a laser welding equipment, presented in fig.1. This is an automated and programmable laser equipment, Nd:YAG type, with the following main characteristics: maximum average power Pmed Max= 120 W; pulse power Ppulse= 5 kW; pulse period Tpulse= 0.3…20.0 ms; pulse frequency fpulse= 0...300 pulses/s, spot diameter: 0.1mm (cutting) and 0.3mm (welding)

- PFO for micro-welding “remote”, superficial heat treatments, etc.

- micro-processing examples: welding special materials (Ta), molds repair, welding experiments for composite single-pulse welding applications, thin film deposition experiments, micro-drilling, micro-alloyed surfacing, making microsurfacing on Ti alloys.

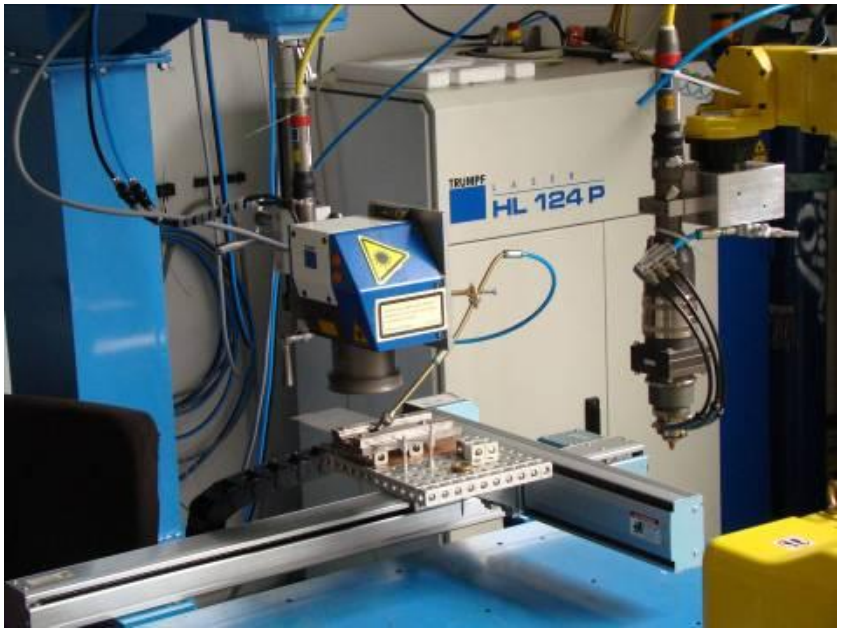

Fig. 1. Laser equipment type HL 124 P LCU

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Technical requirements

The laser soldering preliminary experiment of the components of an electronic board with the sizes 60 mm x 50 mm of a delay relay is described. This is a relatively new and innovative process aimed to special applications.
The components side of the electronic board is presented in the fig. 2, respectively the connection side is shown in fig. 3.

Fig. 2. The upper side, with components of the electronic board

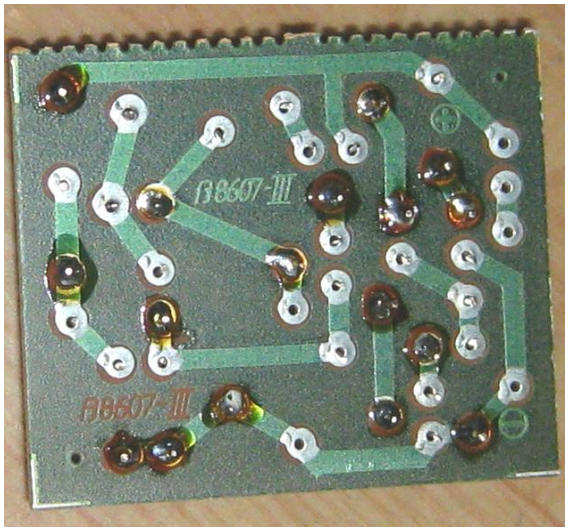

Fig. 3. The bottom side, with connections of the electronic board.

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Laser soldering preliminary experiment

In fig. 4 the laser soldering process is presented. Laser parameters used for bonding are the following: pulse frequency fp= 23...25 pulses/s; pulse period Tpulse= 0.3 ms; pulse peak power Ppulse= 1200…1400 W; upwards defocussing Δf≈ 8 mm; total soldering time ts= 3…8 s. This parameter combination is applied for the thin terminals of transistors and LEDs. In fig. 5 the control unit of the laser equipment is shown.

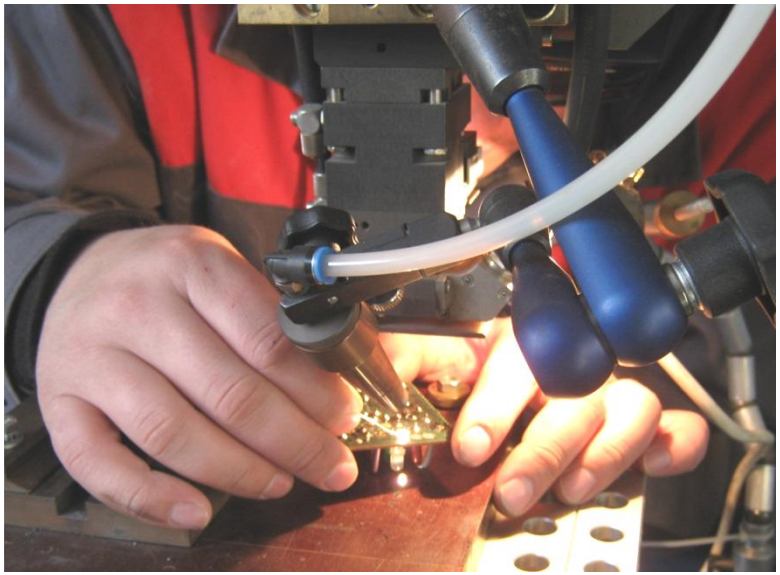

Fig. 4. Laser soldering on a pad of the electronic board.

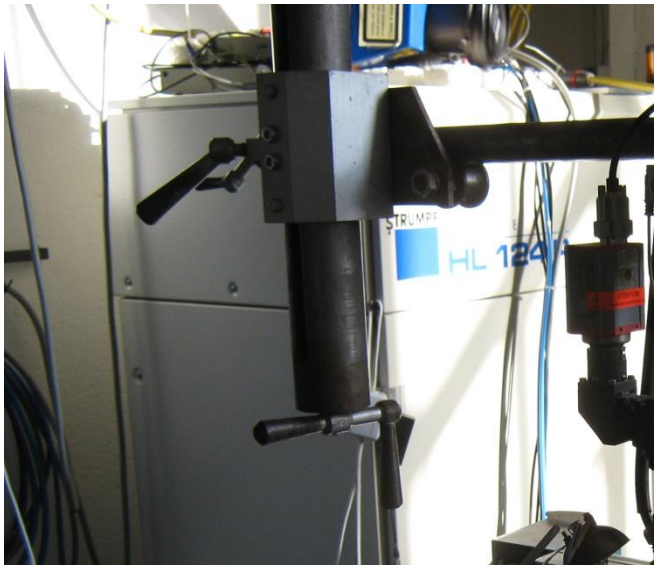

Fig. 5. Control unit of the laser equipment.

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Laser soldering preliminary experiment

Another series of parameters was: pulse frequency fp= 25...28 pulses/s; pulse period Tpulse= 0.3 ms; pulse peak power Ppulse= 1200…1400 W; upwards defocussing Δf≈ 8 mm; total soldering time ts= 3…8 s. The laser soldering process with this set of parameters is illustrated in fig.6. The filler metal is a 0.8 mm wire of the alloy S-Sn96Ag3Cu1.

Fig. 6. Laser soldering on pads with thick terminals of the electronic board.

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Laser soldering preliminary experiment

In fig. 7, the connection side with the soldered pads is presented. This was executed by an innovative soldering process, performed with a laser welding equipment.

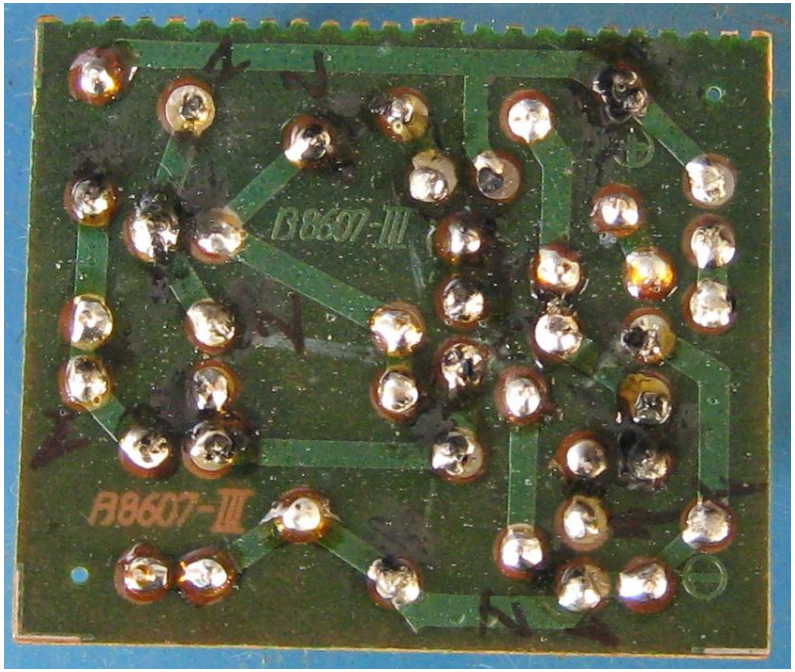

Fig. 7. Connection side with the soldered pads of the electronic board.

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Conclusions

1. The preparation of the PCB prior to soldering operations, as well as placing and fixing the electronic components on the PCB are very important.
2. A precise computer-controlled technology for the execution of the PCB, as well as high quality finishing of the pad surface for the electronic component terminals can allow both good flowing and wetting during the soldering process.
3. In the case of manual soldering operations, using a soldering iron, the PCB must have a correct position, in order to assure the adequate fusion, flowing, wetting and soldering of the drops of filler alloy, onto every pad of terminal, depending on its location and gaps to the neighbouring pads or components.

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Conclusions (continuing)

4. Special care should be taken with process times. A time interval ranging from 1.5 s to 4.2 s might be used, depending on the following factors: pad size, drop size, diameter of the soldering iron tip, power of the Iron, pre-set temperature of the supply station of the soldering iron, etc.
5. To long soldering times can also cause evaporation of certain substances of both the filler alloy and flux, that can affect the technology process.
6. The new experimental ecological filler alloy S-Sn90In7Ag3, elaborated in the frame of the Ecosolder project, has adequate properties regarding fusion, flowing, wetting and solidifying. The soldered joints executed with this new alloy have good appearance, form and sizes, as well as adequate mechanical characteristics.

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References

[1] L. Boțilă; V. Verbițchi et al.: Project ECOSOLDER. MIS Code 1409. „Promoting new ecological filler alloys for soldering, based on the non-ferrous ore of the Romanian-Serbian cross-border area". Technical Report. Stages 1; 2; 3. ISIM Timisoara, Romania. 2013- 2014.

[2] A. Milosavljevic; A. Kostov; R. Todorovic et. al. (MMI Bor, Serbia): "New ecological filler alloy containing indium". Presentation at the Workshop #1, organized by ISIM Timisoara, February 2014.

[3] EN 13599 - Copper plate, sheet and strip for electrical purposes

[4] EN ISO 3677:1995 Filler metal for soft soldering, brazing and braze welding - Designation (ISO 3677:1992).

[5] EN ISO 9453: 2006 Soft solder alloys. Chemical compositions and forms. Compare.

[6] EN ISO 12224-1:1998 Solder wire, solid and flux cored - Specification and test methods - Part 1: Classification and performance requirements (ISO 12224-1:1997).

[7] EN 12799:2000 Brazing - Non-destructive examination of brazed joints (&

[8] ISO 5187:1985 Welding and allied processes - Assemblies made with soft solders and brazing filler metals - Mechanical test methods.

[9] EN 12797:2000 Brazing - Destructive tests of brazed joints (& A1:2003).

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