METALLIC THIN FILMS MICROPROCESSING BY LASER PRECISION TRIMMING

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ABSTRACT

The microelectronics development with new fields of applications like microsystems, sensors and multichip modules. Needs the permanent increasing of miniaturization and the complexity at the chip level.It is looking too for high precision, relatively cheap and small series of production. A modern new, cheaper design concept and manufacturing process will be shown on the paper. The paper deals with the design of the process, the topology design of different types of products on thin films basis The laser processing the metallic thin films of Ni-Cr drawn on a glass substrate. By using laser trimming technology which could be fully automated, the standard procesing technologies like photolitography, mask and etching are not used any more.

KEYWORDS: thin films, microsystems, sensors, laser precision trimming

1. INTRODUCTION

The thin film sensors, multichip modules and Microsystems are need accurate thin active and passive components

After layer deposition and topology design the production process can go in two different ways:

- photolitographical line (in case of large series);
- direct cutting line (in case of short series).

In the latter case the whole topology is cut directly on the NICr layer using the energy of a laser beam or a micro arc discharge of an electro erosion needle. This way the expensive photolithography, mask and etching technological steps can be left out.

For instant thin film resistors, after the photolithographical or cutting processes are still inaccurate. This is caused, first of all by the deviations of sheet resistance and the geometrical sizes.

High accuracy can be reached by post-adjustment. The trimming process is usually based upon changing of plane form of the resistors. The main advantage of this method is that the layer structure remains unchanged and the quality of layer will not deteriorate during the adjusting process.

Placing of discrete elements and packaging of the circuit comes after trimming.

2. THIN FILM LASER TRIMMING WORKSTATION

A new, cheaper design, manufacturing and trimming process used the method the laser direct writing process: the design topology is draw on a glass plate, covered by Ni – Cr resistive layer by a laser beam.

Main parts of the system are following:

- Q – switched Nd:YAG laser equipment for direct cutting;
- co-ordinate table with the substrate holder;
- co-ordinate table controller;
- resistance meter unit with a scanner;
- controlling computer.

The design, manufacturing and trimming processes are fully automated, computer controlled. Fig. 1 shows the picture of thin film laser trimming workstation.

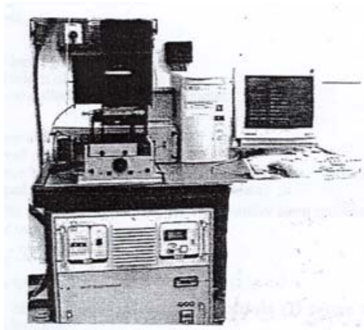


Fig. 1. Direct cutting laser system

3. GENERALLY DESIGN CONDITIONS

The topology designer program designs the layout of the thin film resistor network under the following conditions:

- maximally ten independent resistors can be placed on the chip;
- the topology contains only the resistors, the electrical interconnections between the resistors, other components must be realized on a printed circuit board;
- the output contact points of a resistor may be either the opposite side or the same side of the circuit holder chip;
- the resistor element completely covers the area between its output contacts.

The outline form of the resistor depends on the resistor value:

- ♦ small value resistors can be designed in rectangle form (type 1). In this case, during the trimming process, we decrease the width of the resistor;
- ♦ high value resistors can be designed in meander form. The output contacts of resistor may be the opposite side of the chip (type 2) or the same part of the chip (type 3). In this case, during the trimming process, we open the previously filled loops.

The aim of the designing task is to determine the width of the resistor stripe, the number of meander-loops and, in case of type 3 meanderform, the height of the loop. As the resistor completely covers the area between the output contacts, the length of the resistor stripe can be calculated using the stripe-width and the loopnumber.

The input data of the topology design program are the following:

- sheet resistance of the resistor layer (50….400ohm/sqare);
- minimal width of the resistor stripe. It depends on the cutting technology. In the case of the laser cutting the suggested value is 50μm;
- number of resistors;
- the required value of resistors;
- the outline form of resistors.

The program counts with the 1,2 times nominal resistor value, taking the deviation of the sheet resistance into consideration.

In the case of meander form resistors, the resistor value in the corners of the meanders decreases because of the right angle resistor form.The modified corner resistor value is the 0,599 times smaller like the original one.

The design of product:

$$R = R_\Omega \cdot 1/d = R_\Omega \cdot G \quad (1)$$

Where:
1 is the lenth of resistor stripe
d is the width of resistor stripe
G is the so called geometrical parameter
Let's mark:
H number of loops
d width of resistor
K distance between the output contacts of resistors (n∗2.5, where n 1…9)
c minimal width of resistor stripe (input data)

With these the geometrical parameter of a meander form resistor can be calculated (the distance between the output contact lines is 7.5mm):

$$G = \frac{7.5 - (2\cdot H+1)\cdot d + (2\cdot H+1)\cdot(K+1.8-2\cdot d)}{d} + 2\cdot(2\cdot H+1)\cdot 0.599 \quad (2)$$

Value of G can be calculated also from formula (1) taking the deviation of sheet resistance into consideration:

$$G = 1.2 \cdot R / R_\Omega \quad (3)$$

The maximal width of resistor stripe can be determined:

$$d_{\max} = \frac{7.5 - 0.8 + c}{2\cdot H + 1} - c \quad (4)$$

Substituting (4) for (2) we take a quadratic equation for H

$$H = \frac{-B \pm \sqrt{B^2 - 4\cdot A\cdot D}}{2\cdot A} \quad (5)$$

Where:
A = 4K + 7.528c + 7.2
B = 2cG + 3.764cc + 4K – 3.018
D = K – 6.7G – 3.309

The H value is not on integer, so it must be rounded down. Substituting the H value and G value (3) for (2) the value of resistor can be accurately calculated.

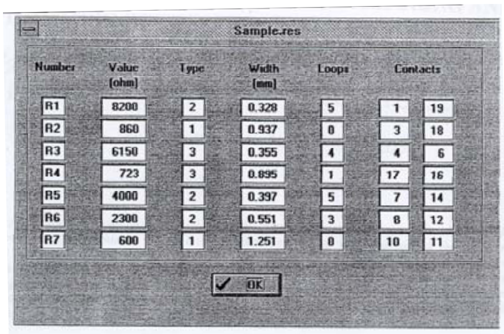
$$d = \frac{7.5 + (2 \cdot H + 1) \cdot (K + 1.8)}{1.2 + R / R_S + 1.882 \cdot (2 \cdot H + 1)} \qquad (6)$$

In the case of rectangular form resistor (type 1) the width of resistor stripe (d) can be calculated from formula (1), taking the deviation of sheet resistance into consideration.

$$d = 1.2 \frac{R_S}{R} \cdot 1 \qquad (7)$$

The topology designer program runs under Windows. The topology can be designed in either automatic or manual mode. In automatic mode, after input of the technological and resistor data, the program calculates and writes on the screen the main parameters of the layout. After it the program draws (or prints out) the designed layout on the screen or printer.

Fig. 2 shows the result of the layout design of a sample network, which contains 7 resistors, Fig. 3 shows the topology of this network.


Sample.res

Number	Value (ohm)	Type	Width (mm)	Loops	Contacts	
R1	8200	2	0.328	5	1	19
R2	860	1	0.937	0	3	18
R3	6150	3	0.355	4	4	6
R4	723	3	0.895	1	17	16
R5	4000	2	0.397	5	7	14
R6	2300	2	0.551	3	8	12
R7	600	1	1.251	0	10	11

OK

Fig. 2. Results of the topology design

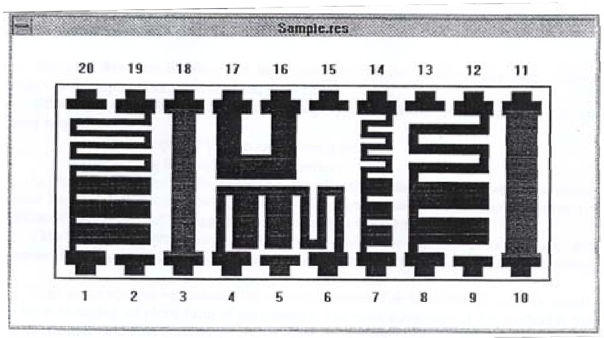


Fig. 3. The designed topology

4. CONCLUSION

The laser trimming technology is a new and modern concept of high precision adjustment of metallic interval structure elements realized of sensors, microsystems and microchip modules (MCM's) realized on the basis of metallic thin films.

The modern design concept and the versatility of laser technology computer assisted are the basis of future development of more innovative high tech products on the microsystems range.

The high precision adjustment and process repeatability with possibility of application for thick films, products and the replacement of obsolete adjustment technology like abrasive jet powders are only a few of advantages of our laser trimming microprocessing.

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