

# Experimental Researches on the Elaboration and the Integration of the Special Procedures and Technologies of Master Mask Generation for Position Incremental Photo-Electrical Sensors Used in Robots and Automated Production Systems

Gheorghe<sup>1</sup>, Gheorghe<sup>1</sup>, Donțu Octavian<sup>2</sup>, Bratu Vasile<sup>3</sup>, Cârstoiu Adriana<sup>4</sup>,  
Istriteanu Simona<sup>5</sup> and Despa Veronica<sup>6</sup>

<sup>1</sup> General Manager of National Institute of Research and Development  
in Mechatronics and Measurement Technique – Bucharest, Romania

<sup>2</sup> University Politehnica of Bucharest, Romania

<sup>3,4</sup> U.V. Targoviste, Romania

<sup>5</sup> The National Institute of Research and Development in Mechatronics  
and Measurement Technique, Bucharest, Romania

<sup>6</sup> U.V. Targoviste, Romania

**Abstract.** The scientific work is a synthesis of the experimental laboratory researches for generating “master masks” for the photoelectrical incremental lasers by elaborating and integrating the procedures and the technologies of special determination of the geometrical configuration by establishing the aligning reticules and the technological routes, of technological quotation, of applying the chemical processing technologies in enabling conditions and in conditions of high accuracy, of control of tracing quality and technological processing and ultra-precise measurement of the obtained measured masks.

**Keywords:** mechatronics, master mask, photo-electrical sensors, automated production, laboratory researches

## 1. Introduction

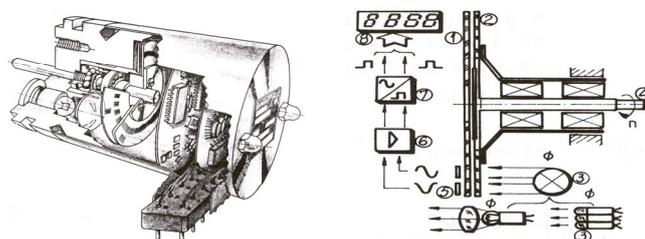


Fig. 1

The precision of the position incremental photo-electrical transducer (fig. 1) is directly dictated by precision of optic disks division, by quality of opaque-transparent contrast, by rectilinear character of transparent-opaque demarcation line as well as geometry of transparent-opaque areas.

The realization of incremental disks (divisor and vernier) is made by the lithographic technique that involves existence of an original mask that multiplies by transferring the image from an optical transparent support on which is laid-down a metal and a photosensitive layer, resulting into the desired configuration, which allows reaching submicronic dimensions.

The work principle for mean of generating routes is impressing by light fascicle of photo sensitive emulsion, from a system with laser ray.

Taking into account that in technology of transferring image mask-sub-layer, photo emulsion enter in direct contact with photoresist and taking in consideration weak mechanical resistance of emulsion, for increasing work life, the work masks has to be copies on chrome of the originals.

This involves that original masks must be positive of disks images.

In conclusion, masks are obtained on photo emulsion, on optical glass support, at 1:1 scale, carrying the positive of disks configurations (with some auxiliary traces imposed on measurement and multiplying technology).

## 2. Master mask laser spot tracing process

The principle of system tracing [PMG R 0101 - pattern generator] is as follows: a laser spot dimensionally controlled, whose symmetry axis is rigorous centered, focalized in photo emulsion plane, is moved on a direction impressing sensitive plaque, which fixed on a gyrating table is angularly moving (particular case of tracing in polar coordinates).

Carrying sub-layer of photosensitive material is fixed in a vacuuming device.

Focalization is made in two stages:

- Manual focalization for bringing with approximation on adjusting range ( $\pm 0,5 \mu\text{m}$ );
- Automate focalization, maintained during tracing for deviations from planarity take-up and perpendicularity at optical axis.

On the entire flow, there are used as photosensitive materials AGFA films on polyester support OP 81 GEVALITH for routine samples, aligning, centering and AGFA films on glass support HOLOTEST 10 E 56 for samples of exposing route samples and final masks.

In term of sensitivity, spectral sensitivity, exposing lamp characteristics, dimensional corrections proposed for routes in optical route are interposed color filters and transmission filters.

The values for wave lengths and transmission coefficients have a theoretical base, being then experimentally adjusted for obtaining desired results on both qualities of film.

## 3. Chemical microtechnologies for master masks processing

Together with exposing and sensitivity of photographic plaque, chemical processing is considered as being the third critical factor in obtaining images with high resolution. Standard technique for processing exposed masks will necessary involve the following stages:

- 1 – alkaline treatment for deantiholoing (variable only for antiholo layer plaques);
- 2 – washing with flowing water (also for plaques with antiholo treatment);
- 3 – developing with continuous swirling;
- 4 – washing in flowing water;
- 5 – fixing in fixing solution with frequent swirling;
- 6 – washing in flowing water;
- 7 – drying.

A typical developing solution will contain: 1 • solvent (which is water); 2 • reducing agent; 3 • activator; 4 • maintaining agent; 5 • modeler.

The basic reaction is reducing granules of silver halide exposed to metallic silver with help of reduction agent, which is a reactive from phenols series (is exemplified by hydroquinone) and in alkaline solution is in a ionized state and in a relatively high concentration (fig. 2).

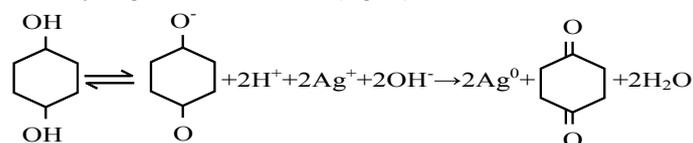


Fig. 2

This reaction begins in latent status image fall into silver halide granules exposed and continue until developing is stopped.

The metallic silver wires resulted produce optical density of image resulted in emulsion. As typical moderator is used potassium bromide which delays developing at unexposed granules level, forming some kind of area electrostatic charged around them, which act as a barrier to reducing agent. Maintaining agent is alkaline antioxidant type sodium sulphite that slows oxidation of active reducing agent and is situated in developing solution in contact with atmospheric oxygen.

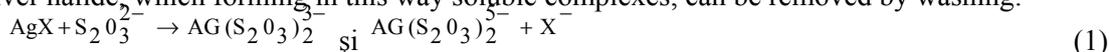
Because the developing reaction is produced especially in emulsion with exposed granules, a slight agitation is indicated to allow fresh developing agent to dispel inside.

The developing reaction can be stopped in the following phase of washing in flowing water and more rapidly, although not indicated (because produces malformations at emulsion level) in slightly acid solutions.

The developing stage is especially critical and necessitates a rigorous control of the process. Selectivity of the silver halide granules towards reducing agent from developer is limited to a short period of time, if the process continues, reduction reaction will continue as well with a decreasing speed until reducing the entire quantity of silver halide, exposed or unexposed to metallic silver.

Practical experience demonstrates that activity degree of developing, time, temperature and agitation state of solution is in connection with quantity of silver developed. Rigorous control of these factors leads to endowment of development baths from processing installations, extra towards other baths (which have submicronic filtering and agitation) with precision thermometers of  $\pm 0,2^{\circ}\text{C}$ , chronometers and pH indicators for activity level of developer. In fixing stage, takes place removing silver halide remained in unexposed areas.

Reaction takes place between salt cake or ammonia sulphate, in water solution of fixing agent in ionized state and silver halide, which forming in this way soluble complexes, can be removed by washing:



Traces of disulphide in emulsion, not removed by washing, can later produce defects of image.

It is very important that no mater which method of drying is used, washing that precedes it to be made in clean water, so after drying to not appear on the mask from previous operations traces of chemicals, reaction products, colorants or other types of materials.

The following are used for basic techniques for drying masks, each with a higher or smaller extension:

- Drying by evaporating water.
- Removing through physical methods of the water
- Dilution with rapid evaporation of the solvent.
- Movement with solvent with high drying speed;
- Replacing water from dried surface with a liquid with superficial low voltage;
- Movement of water droppings at the surface and gathering them in a system with separator, liquid being recirculated.

In studies also appear a variant of this system called “drying with spaces within phases”.

The two phases that participate to water removal can be for example triclorethine and a mixture of alcohol with Freon.

The process takes place as shown in the figure below (fig.3), where there are displayed the six stages if the process that takes place:

- The drop of water from the surface of the plaque that was immersed in solvents mixtures;
- A part of alcohol is extracted from the drop of water;
- Following modification of the density as well as superficial voltage towards plaque, the drop is removed from the plaque and is lifted;
- At the surface is formed a distinct phase from water and alcohol;

- Plaque extracted from solvent, which has on the surface a layer absorbed by the alcohol, Freon which replaced water, this is found on solvent surface in equilibrium with a layer from solvent vapors;

By rapid evaporation at air, this layer is removed.

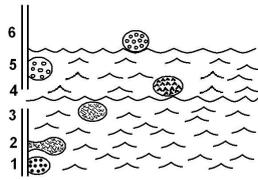


Fig. 3

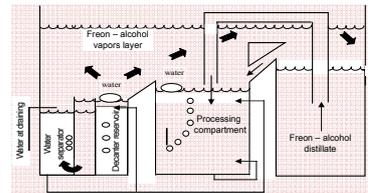


Fig. 4

In figure 4, there is also reproduced a system that realize quick drying of photo plaques by this method.

In figure 5, can be seen the influence of exposure and developing on emulsion thickness. Can be seen at the final phase exposed and developed (d) how as a result of the process appeared thickness differences of opaque areas and there are unwanted especially in transfer through contact method.

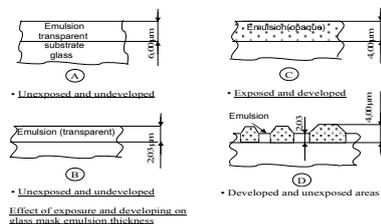


Fig. 5

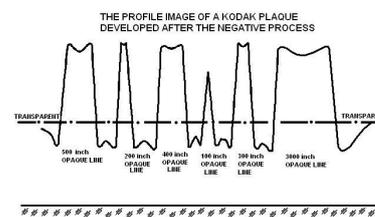


Fig. 6

In figure 6, is reproduced the curve of image profile of a HRP-KODAC plaque – processed by negative process where is observed behavior of emulsion towards light energy absorbed at exposure and who made that line of 100 μm (2,54 μ inch) to have the aspect from the figure.

Moreover, experimentation showed that as line narrows, is less dense, so in the same image of the mask we have wider lines with higher density and narrow and less dense lines. If density control of the mask were made on wider areas, we must have a higher density here to assure convenient values at thicker lines (narrower surfaces). But the differences in density between wider and narrower lines depend on too many factors, and first of all on developing lens.

#### 4. Conditions for practical realizing of processing

Realizing masks processing (AGFA - GEVERT) was made in following stages:

- Developing: 4 minutes at  $20^{\circ}\text{C} \pm 0,1^{\circ}\text{C}$  in developer G 2820 (a part concentrated + 2 parts distilled water);
- Washing in flowing water at  $20^{\circ}\text{C}$  for 2 minutes;
- Fixing in fixative G 333 c (1 part concentrate + 4 parts distilled water at  $20^{\circ}\text{C} \pm 1^{\circ}\text{C}$ , for 2 minutes);
- Washing in flowing water for 10 minutes;
- Drying no. 1 in 25% ethanol + 75% distilled water for 30 seconds;
- Drying no. 2 in 50% ethanol + 50% distilled water for 30 seconds;
- Drying no. 3 in 100% ethanol (absolute ethylic alcohol) for 45 seconds;
- Drying at air in niche with laminar flow for 10 seconds;
- Measuring masks is possible after approximately 1 hour from processing when they reached constant temperature from measuring chamber.

The control of tracing and processing quality was carried out on:

- Stand for measuring lengths with laser interferometer with microscopic visualization [MESMIT 5];

- Stand for measuring angular displacements on divisor tables [ZEISS-OPTON-RT 05] with microscope [X-Y ASAHI];

- interferential microscope [PERAVAL]

Measurement of master mask were carried out on the [PMPGRid] laser stand, with a measuring precision of 0.5 seconds

Verniers errors are:

- for vernier disk, for 1000 divisions/ circumference: + 1 second arc; - 1,5 second arc;
- for vernier disk, for 2000 divisions/ circumference: + 0,5 seconds arc; - 1,5 seconds arc.

Errors of incremental divisor disks (fig. 7 and 8).

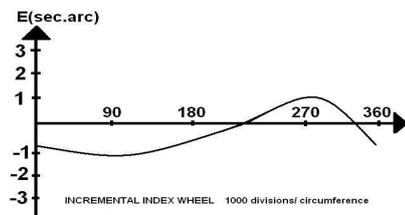


Fig. 7

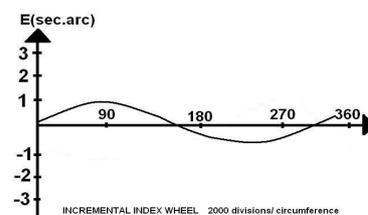


Fig. 8

- for incremental divisor disk with 1000 divisions/ circumference: + 1,5 seconds arc; - 2,5 seconds arc;
- for incremental divisor disk with 2000 divisions/ circumference: + 1,5 seconds arc; - 1,5 seconds arc.

Example of photoelectric incremental master masks divisor and vernier realized with Romanian technology (figure 9)

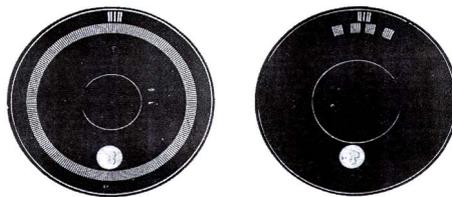


Fig. 9

## 5. Conclusions

The experimental results of the scientific work facilitated the physical realization of master masks for the incremental photoelectric position sensors, contributing to the assimilation and to their multiplication in the industrial fabrication of incremental photoelectric sensors and transducers for ultra-precise angular measurements and positioning.

## 6. References

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