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Optical-mechanical equipment for the defect-free production of reticles

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Present Reticle Production Equipment level Under Develpment

A new complete set of the special process equipment for the defect-free production of reticles is under development. There is DUV multibeam laser pattern generator EM-5389 with minimum feature size 0.2 µm, die-to-database inspection tool with detection capability 65nm and repair system with minimum transparent and opaque defect sizes 0.2 µm. (Fig.1).

The EM-5389 is the next generation scanning multichannel laser pattern generator for mask and reticle production. It is designed to meet production requirements for reticles and photomasks in fabrication. These requirements are to improve writing accuracy, to increase data density and to reduce input data address size. The EM-5389 is an optical generator with the accuracy similar to electron beam generators. The EM-5389 is ideally suited for a fast mask fabrication. High throughput and optical resist processing contribute to shortening the time from the data input to mask fabrication. The pattern generator features an alignment system enabling it to print multilayer phase shifting masks and to fabricate masks in the double masking mode.

In order to ensure a maximum possible and comprehensive defect detection, the EM-6729 inspection tool is provided with an imaging system which allows to get three types of a mask image:

- transmitted light standard contrast image (for binary and EPSM reticle);
- reflected light image;
- phase contrast image (for quartz etch reticles such as alternating, chromeless etc).

On this basis the platform provides several inspection modes, including:

- traditional die-to-database method [2];
- a new method of reflected pattern, transmitted pattern and database comparison, which allows in particular to detect contamination and particles on opaque features of the pattern and also to perform a complete defect classification in automatic mode [3];
- A new Parametric Models of Pattern Features Comparison method (PMoPFC method) [3]. The first of these models corresponds to an optical image (collected from the reticle), the second model is a rendered image (generated from the design data). Such pattern features can be represented both as single figures, as well as figure clusters. This method is especially effective during an inspection of contact holes and via layers, and also during an evaluation of the feature sizes. In particular, during an inspection of contact layers it provides a theoretically detectable transmission defect size on the level of 0.0625 of pixel sizes. In this case a pixel-by-pixel comparison is substituted with the comparison of parametric models of pattern features.

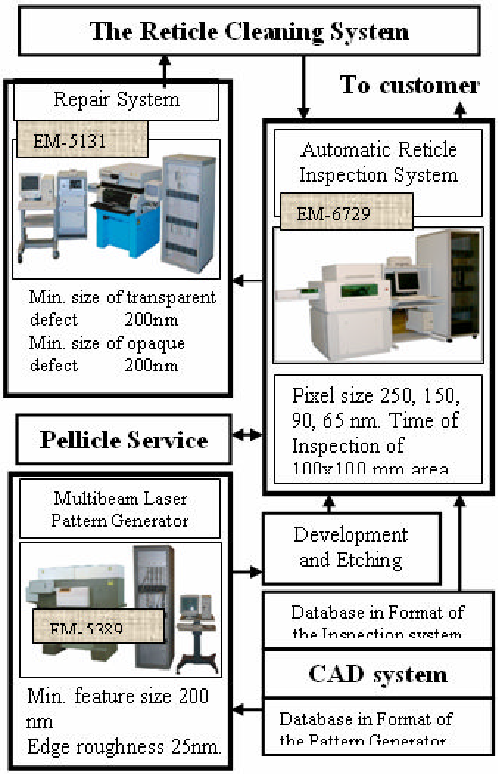

Fig. 1. Optical-mecanical equipment for defectfree production of reticles

The main emphasis during the development was placed on the use of a modular principle which allows in particular to provide a wide range of detection capability without any significant change of the mechanical design.

The principle of modularity realization provides a wide range of applications and a possibility of an optimum adaptation of the tool to the requirements of a customer:

1. A possibility to operate with different pixel sizes in the range of 65 to 250 nm.
2. A possibility to use different types of the reticle loading systems.
3. A possibility to perform a batch processing. It will be possible owing both to an automatic orientation of a reticle and fully automatic defect classification.
4. A possibility to implement feature sizes evaluation mode with integrated Parameters calculation, such as size accuracy, sizes non-linearity, non-linearity of scanning.

Tables 1-6 contain primary parameters of the presented tools - EM-5389, EM-6729, EM-5131.

Table 1. Minimum Feature Size of EM5389.

Parameter of EM-5389	Value
Primary Feature, µm	0.20
Auxiliary Feature, µm	0.15
Pixel Size, µm	0.12

Table 2. Accuracy requirements of EM-5389

Parameter of EM-5389	Valur
Minimum feature size, nm	200
Linewidth uniformity, nm	20
Edge roughness, nm	20
Overlay accuracy, nm	50
Placement error, nm	65
Second-layer Alignment, nm	60

Table 3. Minimum Defect Size of EM-5131.

Parameter of EM-5131	Value
Minimum Opaque Defect, µm	0.2
Minimum Transparent Defect, µm	0.2

Table 4. Detection Capability of EM-6729.

Parameter of EM-6729	Value
Pixel Size, µm	0.25, 0.15, 0.09, 0.065
Detection Threshold for Isolated Defects (P=0,95), µm	0.20, 0.12, 0.065, 0.05
Detection Threshold for Isolated Defects (P=1,00), µm	0.25, 0.15, 0.09, 0.065
Detection Threshold for Adjacent Defects (P=0,95), µm	0.25, 0.15, 0.09, 0.065
Detection Threshold for Adjacent Defects (P=1,00), µm	0.35, 0.20, 0.11, 0.09

Table 5. Database Formats

Format	EM-5389	EM-6729
5x89	+	+
GDS-II	+	+
ZBA	optional	optional
Any Additional Format, Incl., DXF, Gerber, 3600F	optional	optional

Table 6. Throughput, Woking Field, Loading, some service function.

Parameter	EM-5389	EM-5131	EM-6729
Scanning Throughput (time of the scanning of 100x100mm area), pixel size	2.2мм^2/s (1.5hours) 150nm	-	2.5мм^2/s (1.2hours) 65nm
Setup Time, min	20	20	20
Retries Time, min	3	3	3
One Defect View Time (reflected and transmitted light), s	-	4	4
Maximum Size of Working Field of Basic Model, mm	215x215	153x153	153x153
Maximum Pellicles Height of Front Side, mm	-	-	4
Maximum Pellicles Height of Back Side, mm	-	-	4
Possibilities of Optional Increase of Working Field Areas, мм	300x300	900x600	215x215
Semi-automatic	+	+	+
Automatic from one-position cartridge	optional	optional	optional
Automatic from multi-position cartridge	optional	optional	optional
SMIF	+	Optional	+
WEB-Interface Based Testing	optional	optional	optional
GEM/SECS Support	optional	optional	optional
Microclimatic Chamber	optional	optional	optional
Type of Vibroprotection System	optional	optional	optional

Technical Advantages of the Integrated Approach To the Design of equipment

Technical advantages of the integrated approach to the design of such equipment are in the following:

1. There is a possibility to ensure a more comprehensive compatibility of coordinate systems of all machines. This compatibility is achieved through the use of one-type interferometers as well as through the use of the same algorithms to control a coordinate stage motions. A feedback circuit uses one-type interferometric linear motion sensors based on dual-frequency lasers. All these features allow during the pattern automatic inspection to significantly decrease false errors and thereby to increase the inspection adequacy.

2. There is a possibility to implement common approaches in making algorithms to compensate for the coordinate system errors. These include compensations for errors, connected with the environment changes, local inhomogeneity of the masks sizes, variations in parameters during the manufacture of the coordinate systems components.

3. There is a possibility to develop a common system to convert the design data for the pattern generator and the pattern automatic inspection machine. This system also includes a common subsystem to input process allowances for the pattern feature sizes. Design data compatibility between pattern generators on the one hand and the pattern automatic inspection machines on the other, is realized not only at the data format level but also at the level of internal process algorithms. This relates, for instance, to rounding algorithms, algorithms used to shape enveloping profiles, etc. Supplied as a complete set, the pattern generator and the pattern automatic inspection machine are equipped with similar systems of the vector and raster conversion, which fact allows unambiguously to change over from abstract coordinates of the design system to the representation of spatial objects in the equipment.

4. There is a possibility to flexibly change data formats about the defects for the pattern automatic inspection and photomask repair machines, in particular the compatibility in regard to the defect list format.

5. There is a possibility to develop common interfaces and software libraries.

6. There is a possibility to develop control systems on the basis of the same component parts for all three machines. All three machines use a large amount of identical component parts

It is noteworthy to highlight the following economic advantages:

- Easy technical servicing of the machine.
- Reduction of costs in the development and manufacture of the equipment due to the unification of the control systems and software, as well as individual parts of opto-mechanical devices.

References

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The paper presents an integrated solution of a problem to develop a set of the equipment for the defect-free production of reticles and photomasks. The integrated approach to the equipment design allows to obtain certain advantages disclosed below. Accordingly, the paper highlights the following main issues: practical realization of these advantages in the special process equipment developed by the KBTEM-OMO enterprise; advantages in the development of a complete set of the special process equipment. Without taking into account technical and chemical processes, this complete set includes three component parts: Multi-beam laser pattern generator; Die-to-Database reticle inspection system; Laser reticle repair system. Ill. 1, tabl. 6, bibl. 3 (in English; summaries in English, Russian and Lithuanian).

С.М. Аваков, В.В. Жарский, С.Е. Карпович, Е.А. Титко. Оптико-механическое оборудования для бездефектного изготовления фотошаблонов // Электроника и электротехника. – Каунас: Технология, 2008. – № 4(84). – С. 94–96.

Представлен комплексный подход к проблеме проектирования оборудования для бездефектного изготовления фотошаблонов. Такой подход к проектированию позволяет получить некоторые преимущества, описанные ниже. В соответствии с этим, в статье освещены два основных вопроса: преимущества комплексного проектирования специального технологического оборудования; практическая реализация этих преимуществ в спецтехнологическом оборудовании УП «КБТЭМ-ОМО». Без учета техно-химической обработки, комплект включает три единицы оборудования: многоканальный лазерный генератор изображений; установку автоматического контроля топологии; установку устранения дефектов. Ил. 1, табл. 6, библ. 3 (на английском языке; рефераты на английском, русском и литовском яз.).

S.M. Avakaw, V.V. Jarsky, S.E. Karpovich, A.A. Tsitko. Optinės mechaninės skalių įrangos be defektų gamybos tyrimas // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2008. – Nr. 4(84). – P. 94–96.

Aprašoma problema, susijusi su optinių mechanizmų staklių gamybinių procesų įrangos optimaliu parinkimu. Integruoto proceso gamybos būdas turi tam tikrus pranašumus, nes jie įgyvendinti KBTEM-OMO įmonės; užbaigto proceso įrangos komplekto panaudojimu. Neatsižvelgdamas į techninius ir cheminius procesus, šis užbaigtas įrangos komplektas apima tris komponentus: multispinduliuotę lazerinį struktūros generatorių; lazerinė skalės remonto sistemą ir defektų pašalinimo įrangą. Ill. 1, lent. 6, bibl. 3 (anglų k.; santraukos anglų, rusų ir lietuvių k.).

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