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(54) **OPC OPERATION METHOD AND OPC OPERATION DEVICE**

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G06K 9/62	(2006.01)
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(52) **U.S. Cl.**

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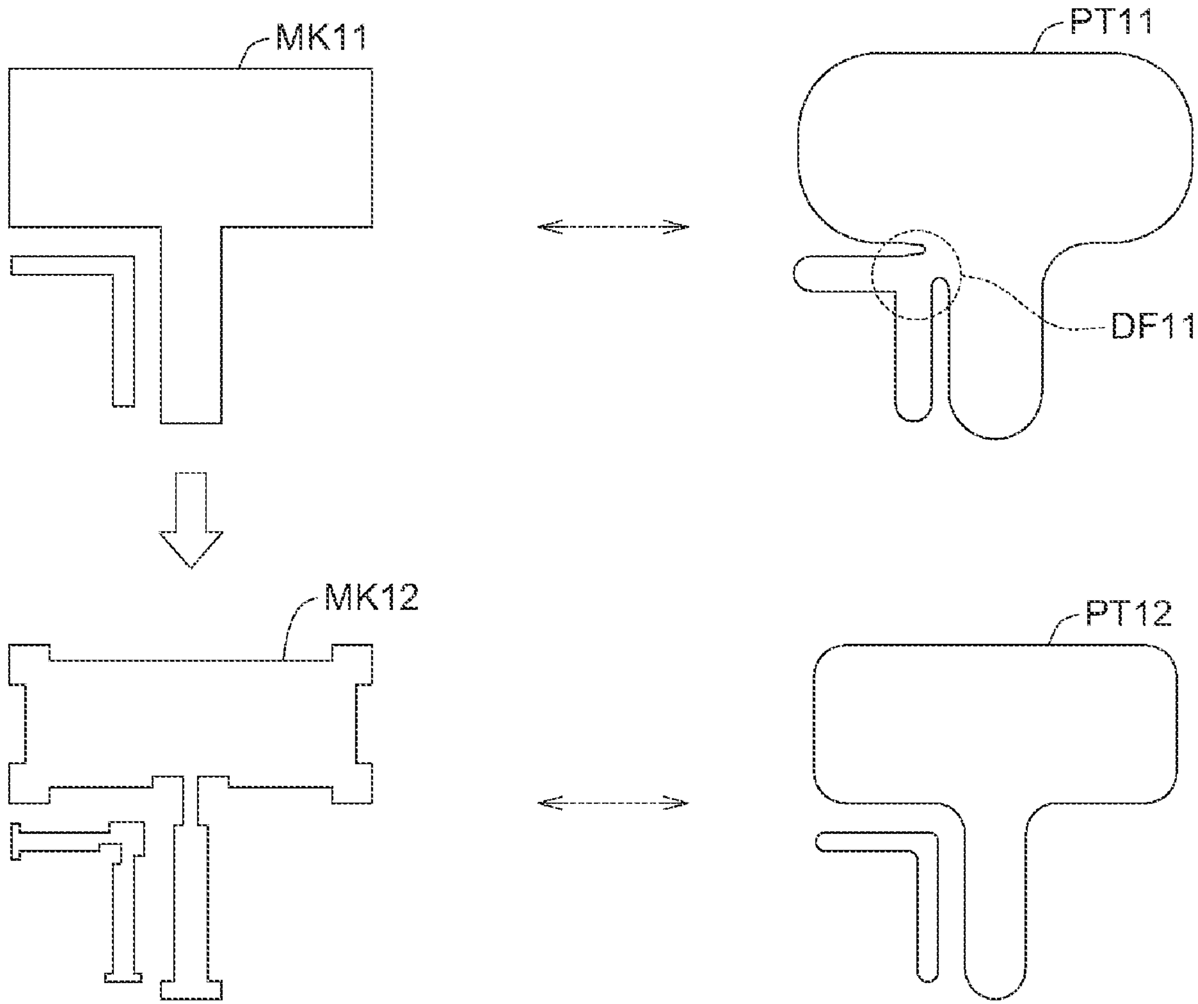
(57) **ABSTRACT**

An optical proximity correction (OPC) operation method and an OPC operation device are provided. The OPC operation method includes the following steps. A mask layout is obtained. If the mask layout contains at least one defect hotspot, at least one partial area pattern is extracted from the mask layout according to the at least defect hotspot. A machine learning model is used to analyze the local area pattern to obtain at least one OPC strategy. The OPC strategy is implemented to correct the mask layout.



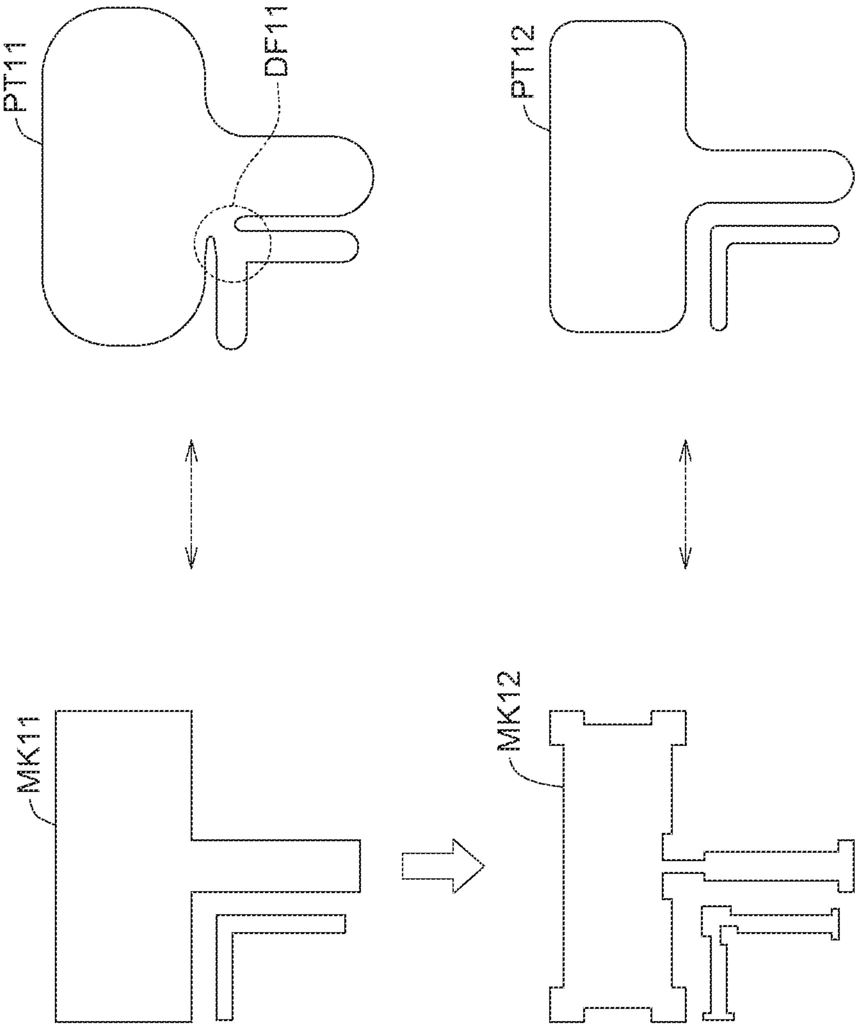


FIG. 1

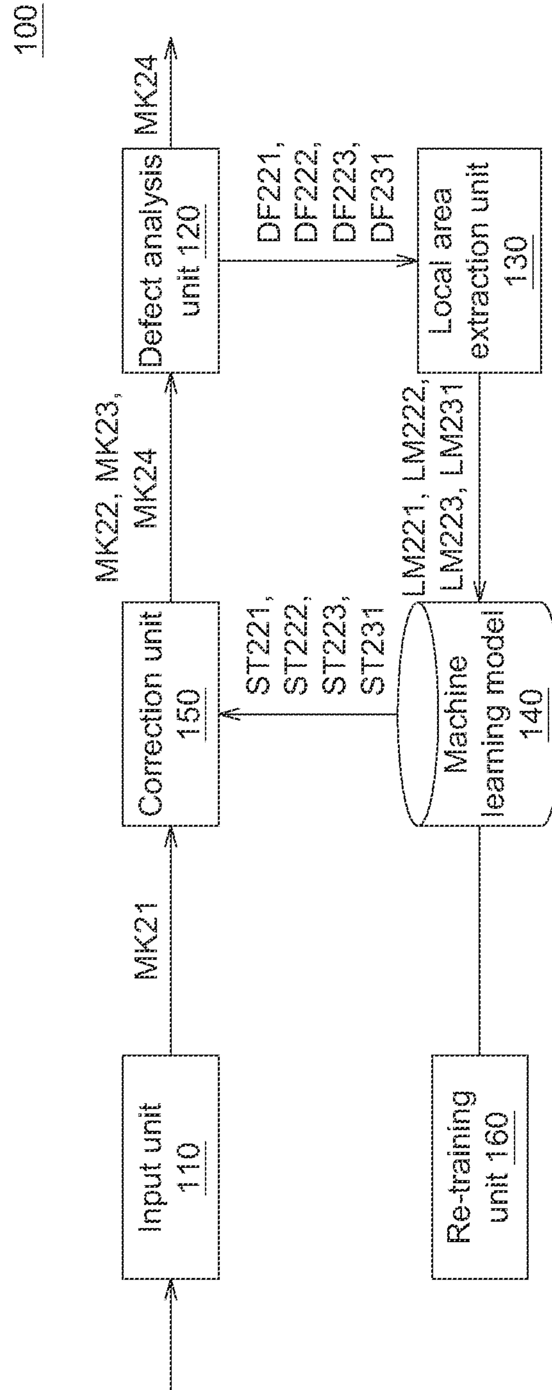


FIG. 2

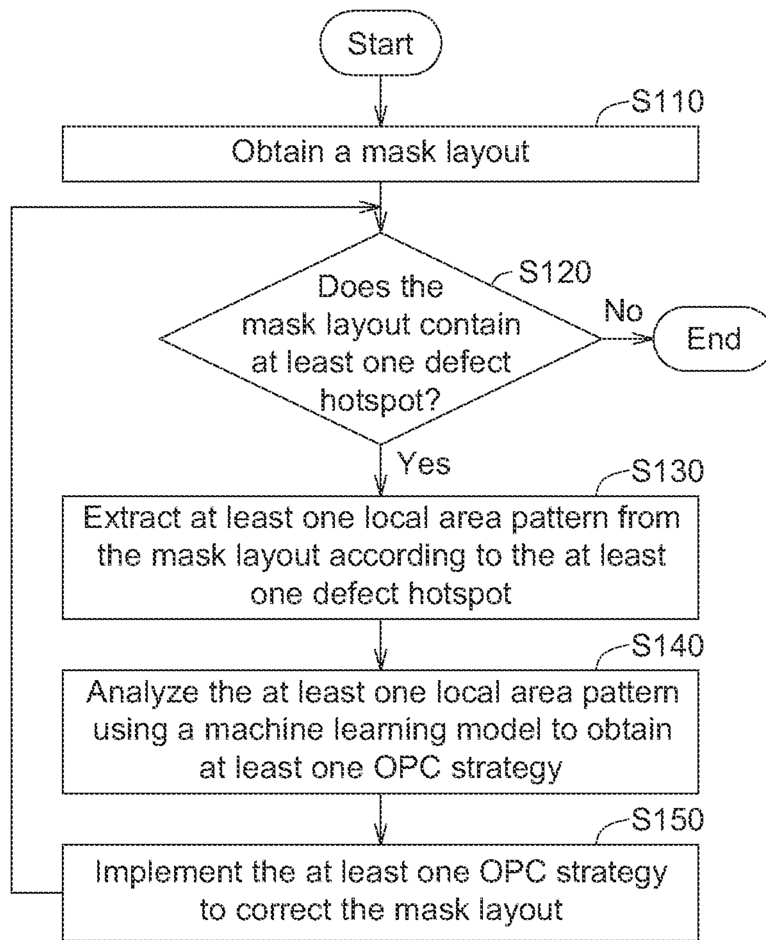


FIG. 3

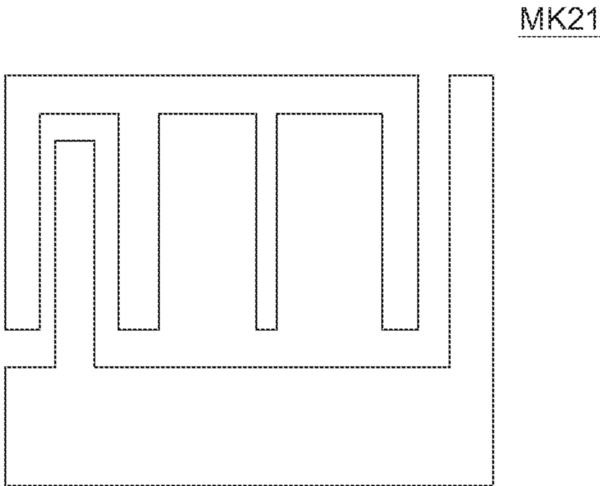


FIG. 4

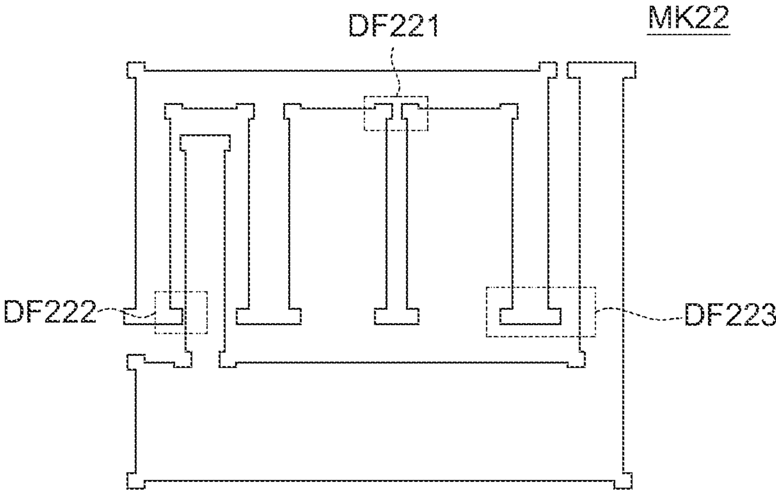


FIG. 5

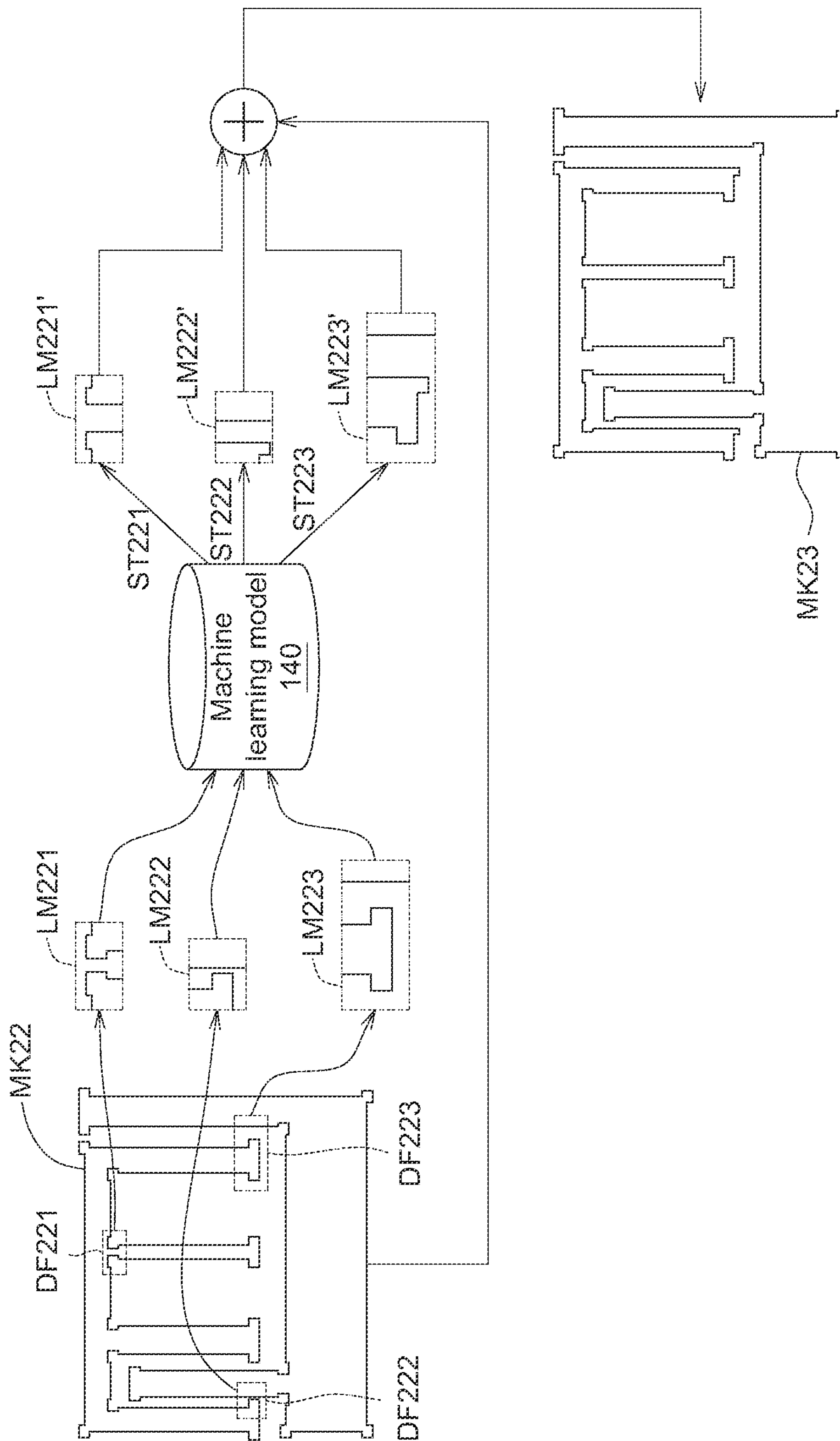


FIG. 6

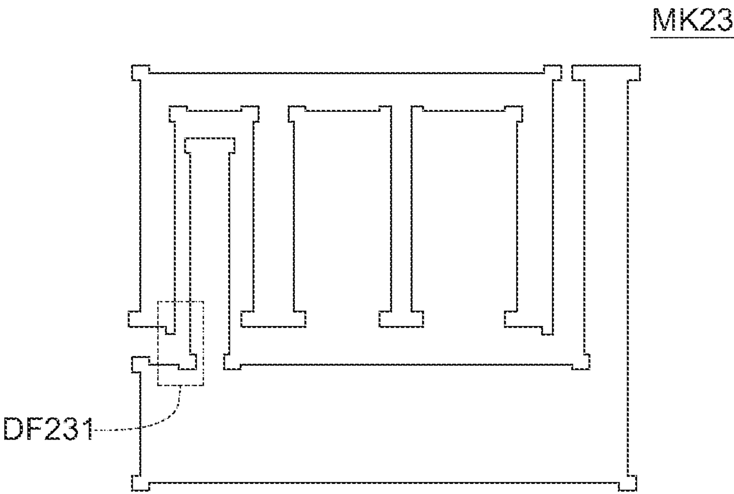


FIG. 7

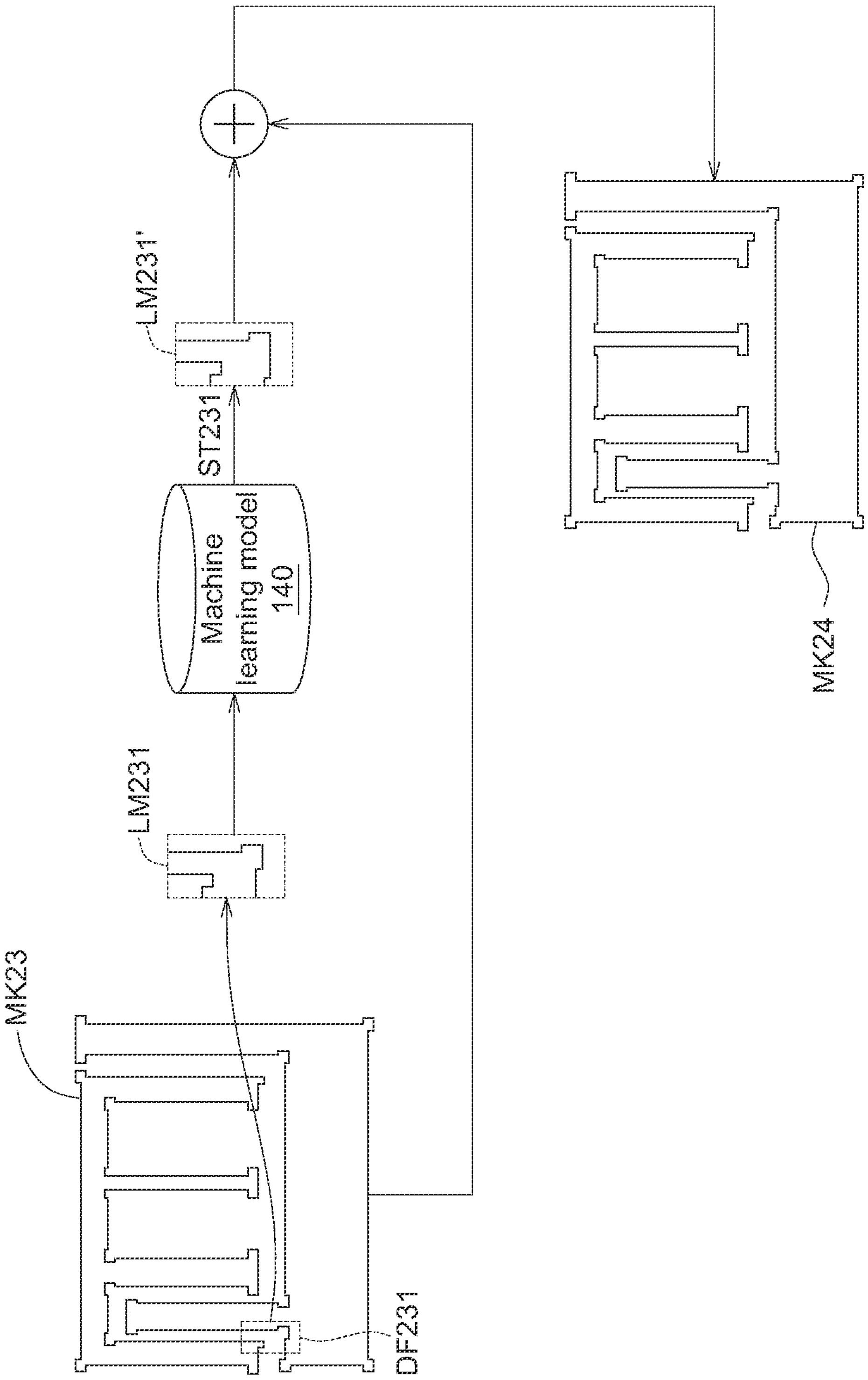


FIG. 8

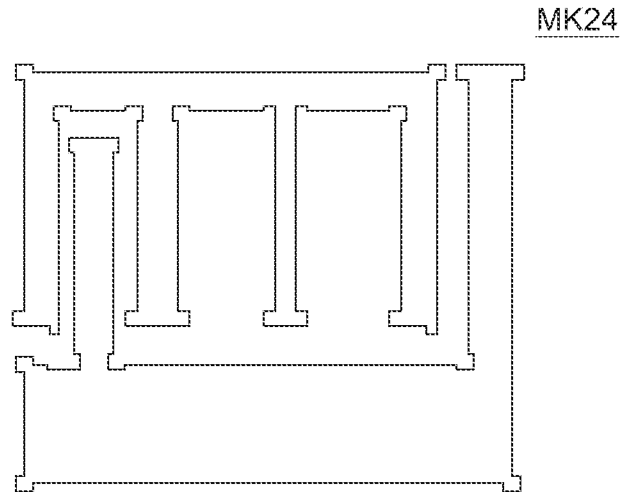


FIG. 9

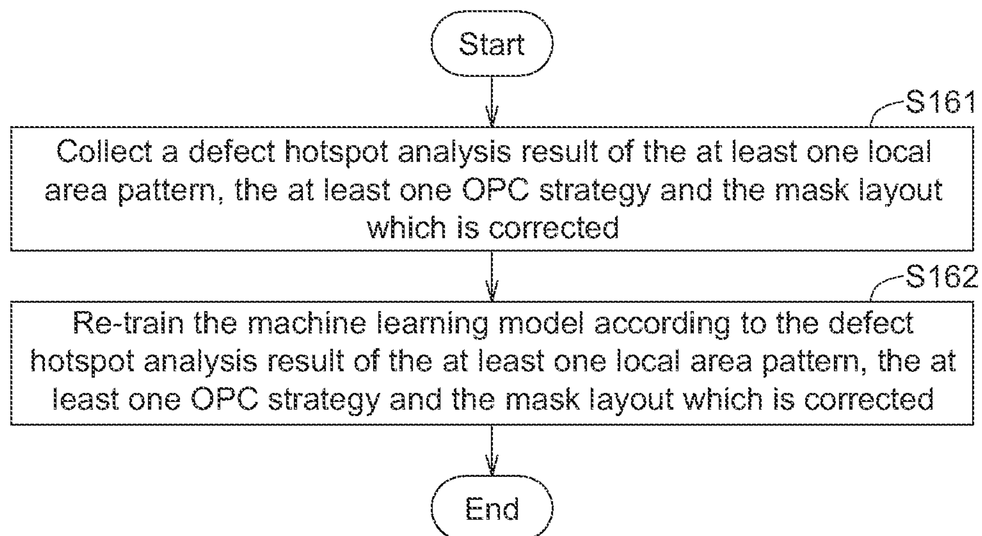


FIG. 10

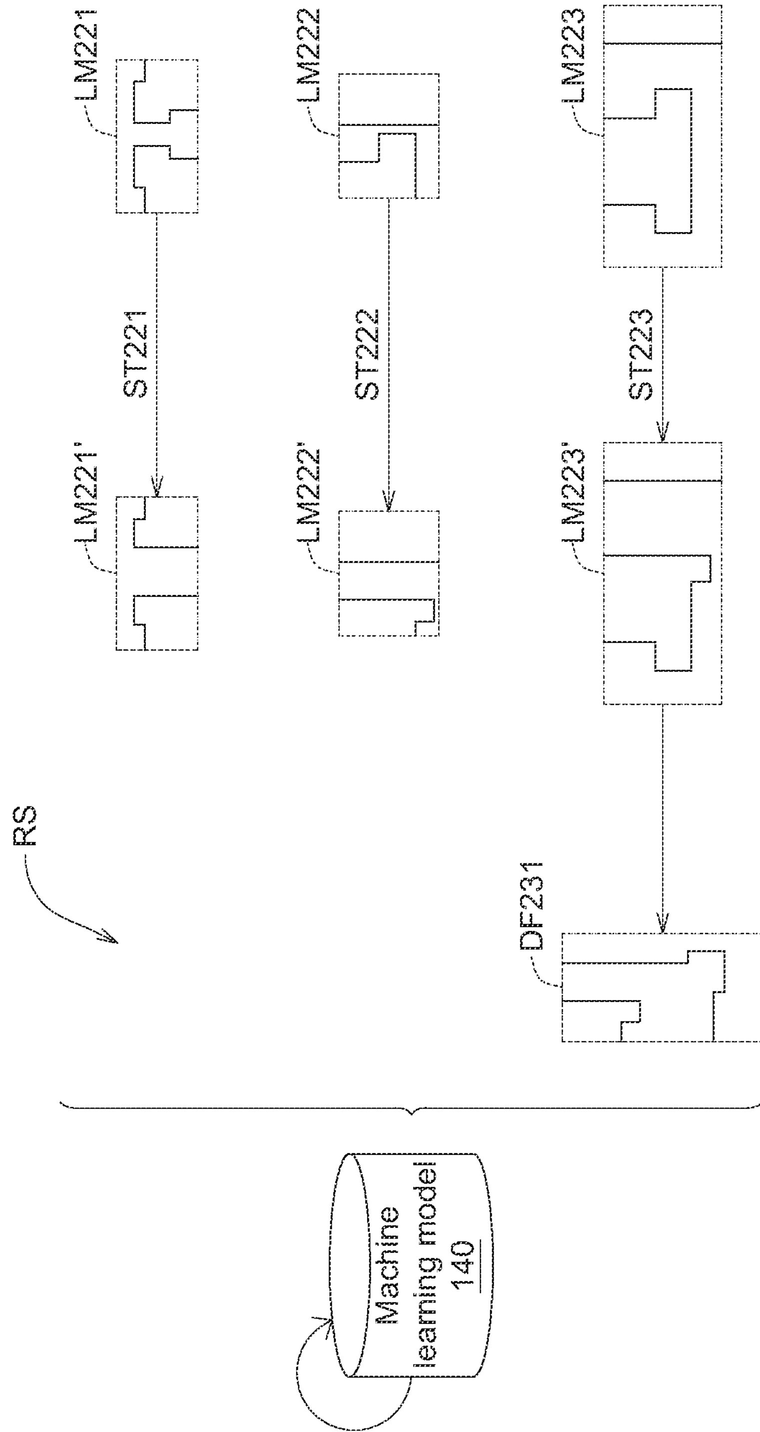


FIG. 11

OPC OPERATION METHOD AND OPC OPERATION DEVICE

[0001] This application claims the benefit of People's Republic of China application Serial No. 202110533878.1, filed May 17, 2021, the subject matter of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The invention relates in general to an operation method and operation device, and more particularly to an optical proximity correction (OPC) operation method and an OPC operation device.

Description of the Related Art

[0003] Photolithography is an important step in the semiconductor process. During photolithography, predetermined photoresist pattern is developed on the photoresist layer by defining exposure region and non-exposure region on the mask pattern of the mask. During the etching process, traces can be etched using the photoresist pattern. However, if the etched traces contain defects, caused by such as disconnection or short-circuiting, the mask pattern needs to be corrected using optical proximity correction (OPC). The purpose of OPC is to make the etched traces consistent with the predetermined circuit pattern and be free of defects.

[0004] However, different defects and different patterns may require different OPC strategies. Conventionally, the determination of the OPC strategies relies on the operator's judgement, not only easily resulting in an erroneous judgement but also making it difficult to accumulate the experiences.

SUMMARY OF THE INVENTION

[0005] The invention is directed to an optical proximity correction (OPC) operation method and an OPC operation device. Facing various mask patterns, the OPC operation method and operation device of the invention are capable of analyzing one or more local area patterns to obtain one or more corresponding OPC strategies using a machine learning model without relying on the operator's judgement, not only making the judgement more accurate but also accumulating the experiences.

[0006] According to one embodiment of the present invention, an optical proximity correction (OPC) operation method is provided. The OPC operation method includes the following steps. A mask layout is obtained. If the mask layout contains at least one defect hotspot, at least one partial area pattern is extracted from the mask layout according to the at least defect hotspot. A machine learning model is used to analyze the local area pattern to obtain at least one OPC strategy. The OPC strategy is implemented to correct the mask layout.

[0007] According to another embodiment of the present invention, an optical proximity correction (OPC) operation device is provided. The OPC operation device includes an input unit, a local area extraction unit, a machine learning model and a correction unit. The input unit is used to obtain a mask layout. If the mask layout contains at least one defect hotspot, the local area extraction unit extracts at least one local area pattern according to the defect hotspot. The machine learning model is used to analyze the local area pattern to obtain at least one OPC strategy. The correction unit is used to implement the OPC strategy to correct the mask layout.

[0008] The above and other aspects of the invention will become better understood with regard to the following detailed description of the preferred but non-limiting embodiment(s). The following description is made with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** is a schematic diagram of an OPC according to an embodiment.

[0010] FIG. **2** is a schematic diagram of an OPC operation device according to an embodiment.

[0011] FIG. **3** is a flowchart of an OPC operation method according to an embodiment.

[0012] FIGS. **4** to **9** illustrate each step of FIG. **3**.

[0013] FIG. **10** is a flowchart of a re-training method of a machine learning model according to an embodiment.

[0014] FIG. **11** illustrate each step of FIG. **10**.

DETAILED DESCRIPTION OF THE INVENTION

[0015] Referring to FIG. **1**, a schematic diagram of an OPC according to an embodiment is shown. The OPC technology mainly is for correcting the mask pattern. The purpose of OPC is for making the etched traces consistent with the predetermined circuit pattern and free of defects. As indicated in FIG. **1**, after the exposing process, the developing process and the etching process are performed using the mask pattern MK**11**, a circuit pattern PT**11** can be obtained. A defect hotspot DF**11** caused by bridging can be found on the circuit pattern PT**11**.

[0016] To avoid the defect hotspot DF**11**, the research personnel corrects the mask pattern MK**11** as a mask pattern MK**12** using a particular OPC strategy. As indicated in FIG. **1**, after the exposing process, the developing process and the etching process are performed using the mask pattern MK**12**, a circuit pattern PT**12** can be obtained. The circuit pattern PT**12** no longer contains the defect hotspot DF**11**. However, the defect hotspot has many implementations, and both the density and the curvature of the traces affect the circuit pattern. Therefore, with respect to various situations, it is difficult to determine which OPC strategy is most suitable.

[0017] Referring to FIG. **2**, a schematic diagram of an OPC operation device **100** according to an embodiment is shown. The OPC operation device **100** includes an input unit **110**, a defect analysis unit **120**, a local area extraction unit **130**, a machine learning model **140**, a correction unit **150** and a re-training unit **160**. Detailed descriptions of the function of each element are disclosed below. The input unit **110** is used to input data. The defect analysis unit **120** is used to perform a defect analysis. The local area extraction unit **130** is used to divide local area patterns. The machine learning model **140** is used to perform an image analysis or a recognition procedure. The correction unit **150** is used to perform an OPC. The re-training unit **160** is used to re-train the machine learning model **140**. The input unit **110** can be realized by a database, a transmission line, a network cable or a wireless transmission module. The defect analysis unit **120**, the local area extraction unit **130**, the machine learning model **140**, the correction unit **150** and/or the re-training unit

160 can be realized by a circuit, a chip, a circuit board, a code, or a storage device for storing programming codes. During the operation of the OPC operation device **100**, the machine learning model **140** can analyze at least one local area pattern to obtain at least one OPC strategy. Detailed operations of each element are disclosed below with an accompanying flowchart.

[0018] Refer to FIGS. **3** to **9**. FIG. **3** is a flowchart of an OPC operation method according to an embodiment. FIGS. **4** to **9** illustrate steps S**110** to S**150** of FIG. **3**. In step S**110** as indicated in FIG. **4**, a mask layout MK**21** is obtained by the input unit **110**, wherein the mask layout MK**21** can be a GDS file. Before correction, the mask layout MK**21** has even edges. According to the descriptions of FIG. **1**, the uncorrected mask layout MK**21** may generate defect hotspots caused by such as short-circuiting, disconnection or bridging. Therefore, the correction unit **150** can perform a thorough correction on the mask layout MK**21** using a basic OPC strategy to obtain a mask layout MK**22** of FIG. **5**.

[0019] Then, the method proceeds to step S**120** as indicated in FIG. **5**, whether the mask layout MK**22** contains any defect hotspots is determined by the defect analysis unit **120**. If the mask layout MK**22** does not contain any defect hotspots, then the method terminates. If the mask layout MK**22** contains some defect hotspots, then the method proceeds to S**130**. The mask layout MK**22** may contain one or more defect hotspots. As indicated in FIG. **5**, the mask layout MK**22** contains three defect hotspots DF**221**, DF**222** and DF**223**. For example, the defect hotspot DF**221** is caused by disconnection, and the defect hotspot DF**222** and the defect hotspot DF**223** are caused by bridging.

[0020] In step S**130** as indicated in FIG. **6**, local area patterns LM**221**, LM**222** and LM**223** are extracted by the local area extraction unit **130** according to the defect hotspots DF**221**, DF**222** and DF**223**. The local area patterns LM**221**, LM**222** and LM**223** are adjacent areas of the defect hotspots DF**221**, DF**222** and DF**223**; they do not form the entire mask layout MK**22**. The sizes of the local area patterns LM**221**, LM**222** and LM**223** can be identical or different. The sizes of the local area patterns LM**221**, LM**222** and LM**223** can be 5 to 20 times of the line width.

[0021] Then, the method proceeds to step S**140** as indicated in FIG. **6**, the local area patterns LM**221**, LM**222** and LM**223** are analyzed by the machine learning model **140** to obtain OPC strategies ST**221**, ST**222** and ST**223**. The OPC strategy ST**221** is used to correct the local area pattern LM**221** to avoid the occurrence of disconnection. The OPC strategies ST**222** are ST**223** are used to correct local area patterns LM**222** and LM**223** to avoid the occurrence of bridging. The OPC strategies ST**221**, ST**222** and ST**223** can be completely identical, completely different or partly identical. Besides, with respect to the same local area pattern, the machine learning model **140** can analyze several OPC strategies from which an optimum OPC strategy can be determined using a cost analysis method.

[0022] Then, the method proceeds to step S**150** as indicated in FIG. **6**, the OPC strategies ST**221**, ST**222** and ST**223** are implemented by the correction unit **150** to correct the mask layout MK**22**. In the present step, the OPC strategies ST**221**, ST**222** and ST**223** are implemented by the correction unit **150** on the local area patterns LM**221**, LM**222** and LM**223** to obtain corrected local area patterns LM**221'**, LM**222'** and LM**223'**. The correction unit **150** further merges the corrected local area patterns LM**221'**, LM**222'** and LM**223'** to the mask layout MK**22** to obtain a mask pattern LM**23** of FIG. **7**. In the present step, the OPC strategies ST**221**, ST**222** and ST**223** can be concurrently or sequentially implemented.

[0023] In another embodiment, the process of merging the corrected local area patterns LM**221'**, LM**222'** and LM**223'** to the mask layout MK**22** can be omitted, and the OPC strategies ST**221**, ST**222** and ST**223** can be sequentially and directly implemented on the entire mask layout MK**22**.

[0024] Then, the method returns to step S**120**. In step S**120** as indicated in FIG. **7**, whether the mask layout MK**23** contains any defect hotspots is determined by the defect analysis unit **120**. If the mask layout MK**23** does not contain any defect hotspots, then the method terminates. If the mask layout MK**23** contains some defect hotspots, then the method proceeds to S**130**. As indicated in FIG. **7**, the mask layout MK**23** contains a defect hotspot DF**231** corresponding to the corrected local area pattern LM**222'**. That is, the mask layout MK**23** still needs to be corrected.

[0025] In step S**130** as indicated in FIG. **8**, the local area pattern LM**231** is extracted by the local area extraction unit **130** according to the defect hotspot DF**2**.

[0026] Then, the method proceeds to step S**140** as indicated in FIG. **8**, the local area pattern LM**231** is analyzed by the machine learning model **140** to obtain an OPC strategy ST**231**.

[0027] Then, the method proceeds to step S**150** as indicated in FIG. **8**, the OPC strategy ST**231** is implemented by the correction unit **150** to correct the mask layout MK**23**. In the present step, the correction unit **150** implements the OPC strategy ST**231** on the local area pattern LM**231** to obtain a corrected local area pattern LM**231'**. The correction unit **150** further merges the corrected local area pattern LM**231'** to the mask layout LM**23** to obtain the mask layout MK**24** of FIG. **9**.

[0028] Then, the method returns to step S**120**. In step S**120** as indicated in FIG. **9**, whether the mask layout MK**24** contains any defect hotspots is determined by the defect analysis unit **120**. If the mask layout MK**24** does not contain any defect hotspots, then the method terminates. If the mask layout MK**24** contains some defect hotspots, then the method proceeds to S**130**. As indicated in FIG. **9**, the mask layout MK**24** does not contain any defect hotspots, therefore the method terminates.

[0029] According to above embodiments, with respect to various mask patterns, the machine learning model **140** can analyze one or more local area patterns to obtain one or more corresponding OPC strategies instead of determining the OPC strategies according to the operator's judgement, such that the determination of OPC strategies is more accurate and the experiences can be accumulated. Details of accumulating the experiences to re-train the machine learning model **140** are disclosed below.

[0030] Refer to FIGS. **10** to **11**. FIG. **10** is a flowchart of a re-training method of a machine learning model **140** according to an embodiment. FIG. **11** illustrate each step of FIG. **10**. In step S**161**, a defect hotspot analysis result RS of the local area patterns LM**221**, LM**222** and LM**223**, the OPC strategies ST**221**, ST**222** and ST**223** and the corrected local area patterns LM**221'**, LM**222'** and LM**223'** is collected. In step S**162**, the machine learning model **140** is re-trained by the re-training unit **160** according to the defect hotspot analysis result RS of the local area patterns LM**221**, LM**222** and LM**223**, the OPC strategies ST**221**, ST**222** and ST**223**

and the corrected local area patterns LM**221'**, LM**222'** and LM**223'**. For example, the local area patterns LM**221'** and LM**222'** do not contain any defect hotspots, but the local area pattern LM**223'** contains the defect hotspot DF**231**. The defect hotspot analysis result RS is the ground truth of the training data. The machine learning model **140** can be re-trained using these data to accumulate experiences and increase the accuracy of analysis.

[0031] While the invention has been described by way of example and in terms of the preferred embodiment(s), it is to be understood that the invention is not limited thereto. On the contrary, it is intended to cover various modifications and similar arrangements and procedures, and the scope of the appended claims therefore should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements and procedures.

What is claimed is:

1. An optical proximity correction (OPC) operation method, comprising:
obtaining a mask layout;
if the mask layout contains at least one defect hotspot, extracting at least one local area pattern from the mask layout according to the at least one defect hotspot;
analyzing the at least one local area pattern using a machine learning model to obtain at least one OPC strategy; and
implementing the at least one OPC strategy to correct the mask layout.

2. The OPC operation method according to claim **1**, wherein a quantity of the at least one local area pattern extracted from the mask layout is greater than 1.

3. The OPC operation method according to claim **2**, wherein a quantity of the at least one OPC strategy obtained by analyzing the local area patterns using the machine learning model is greater than 1.

4. The OPC operation method according to claim **3**, wherein the OPC strategies are not identical.

5. The OPC operation method according to claim **3**, wherein some of the OPC strategies are identical.

6. The OPC operation method according to claim **3**, wherein the OPC strategies are concurrently implemented to correct the mask layout.

7. The OPC operation method according to claim **1**, wherein the step of implementing the at least one OPC strategy to correct the mask layout comprises:
implementing the at least one OPC strategy on the local area pattern to correct the at least one local area pattern; and
merging the at least one local area pattern which is corrected to the mask layout to correct the mask layout.

8. The OPC operation method according to claim **1**, wherein the step of implementing the at least one OPC strategy to correct the mask layout comprises:
implementing the at least one OPC strategy on the mask layout to correct the mask layout.

9. The OPC operation method according to claim **1**, further comprising:
collecting a defect hotspot analysis result of the at least one local area pattern, the at least one OPC strategy and the mask layout which is corrected; and
re-training the machine learning model according to the defect hotspot analysis result of the at least one local area pattern, the at least one OPC strategy and the mask layout which is corrected.

10. An optical proximity correction (OPC) operation device, comprising:
an input unit configured to obtain a mask layout;
a local area extraction unit configured to extract at least one local area pattern according to at least one defect hotspot if the mask layout contains the at least one defect hotspot;
a machine learning model configured to analyze the at least one local area pattern to obtain at least one OPC strategy; and
a correction unit configured to implement the at least one OPC strategy to correct the mask layout.

11. The OPC operation device according to claim **10**, wherein a quantity of the at least one local area pattern extracted from the mask layout by the local area extraction unit is greater than 1.

12. The OPC operation device according to claim **11**, wherein a quantity of the at least one OPC strategy obtained by analyzing the local area patterns using the machine learning model is greater than 1.

13. The OPC operation device according to claim **12**, wherein the OPC strategies are not identical.

14. The OPC operation device according to claim **12**, wherein some of the OPC strategies are identical.

15. The OPC operation device according to claim **12**, wherein the OPC strategies are concurrently implemented to correct the mask layout.

16. The OPC operation device according to claim **10**, wherein the correction unit implements the at least one OPC strategy on the local area pattern to correct the at least one local area pattern and further merges the at least one local area pattern which is corrected to the mask layout to correct the mask layout.

17. The OPC operation device according to claim **10**, wherein the correction unit implements the at least one OPC strategy on the mask layout to correct the mask layout.

18. The OPC operation device according to claim **10**, further comprising:
a re-training unit configured to re-train the machine learning model according to a defect hotspot analysis result of the at least one local area pattern, the at least one OPC strategy and the mask layout which is corrected.

* * * * *