BESCHWERDEKAMMERN DES EUROPÄISCHEN PATENTAMTS | BOARDS OF APPEAL OF THE EUROPEAN PATENT OFFICE | CHAMBRES DE RECOURS DE L'OFFICE EUROPEEN DES BREVETS

Internal distribution code:
(A) [ ] Publication in OJ
(B) [ ] To Chairmen and Members
(C) [ ] To Chairmen
(D) [X] No distribution

Datasheet for the decision of 31 January 2007

Case Number: T 0901/05 - 3.4.03

Application Number: 95304249.6

Publication Number: 0698916

IPC: H01L 21/027

Language of the proceedings: EN

Title of invention:
Method of optical lithography using phase shift masking

Applicant:
ADVANCED MICRO DEVICES, INC.

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (no)"

Decisions cited:
-

Catchword:
-

Europäisches Patentamt | European Patent Office | Office européen des brevets

Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 0901/05 - 3.4.03

D E C I S I O N
of the Technical Board of Appeal 3.4.03
of 31 January 2007

Appellant: ADVANCED MICRO DEVICES, INC.
One AMD Place
P.O. Box 3453
Sunnyvale
California 94088-3453 (US)

Representative: Grünecker, Kindeldey
Stockmair & Schwanhäusser
Anwaltssozietät
Maximilianstraße 58
D-80538 München (DE)

Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 1 February 2005 refusing European application No. 95304249.6 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: G. Eliasson
Members: V. L. P. Frank
U. Tronser

Summary of Facts and Submissions

I. This is an appeal from the refusal of European patent application 95 304 249.6 for lack of inventive step (Article 56 EPC).

II. In reply to a communication of the board the appellant applicant filed amended main and auxiliary claim requests 1 to 4 by letter of 29 December 2006.

III. At oral proceedings before the board the appellant applicant only requested that the decision under appeal be set aside and that a patent be granted in the following version:

claims according to the main request or one of the auxiliary requests 1 or 4, with the deletion of "in an I-line stepper" in claim 1 of auxiliary request 4, all requests filed by letter of 29 December 2006.

IV. Claim 1 of the main request reads:

> "A lithography method for phase shift mask patterning for forming the levels of an integrated circuit (IC) on a semiconductor wafer, said lithography method including use of different masks (102, 107) to pattern the layout of different levels, one such level being the gate level (40-49) and a second such level being the active regions (30-38), said active regions being spatially defined by an active region layout pattern, said gate level having a gate level layout pattern and being spatially defined by a first and second gate level layout pattern portion,

said first gate level layout pattern portion being a standard non-phase shift mask pattern having opaque and non-opaque regions and said second gate level layout pattern portion having areas containing phase shift regions, said method comprising:

performing an automated computer implemented comparative analysis of said active regions layout pattern and said first gate level layout pattern portion to spatially establish the location of Intersection regions corresponding to the regions on the IC where said active region layout pattern and said first gate level layout pattern portion overlay, said Intersection regions being rectangles having a pair of parallel long sides and a pair of parallel short sides;

performing automated computer implemented phase assignments under predefined constraints to assign zero and 180 degree phase shift regions such that said zero degree phase shift regions are contiguous with one side of each said pair of parallel long sides of the rectangle of said Intersection regions and said 180 degree phase shift regions are contiguous with the other side of each said pair of parallel long sides of said rectangle of said Intersection regions so as to apply the alternating phase shifter only to those regions of the gate level overlying the active region layout pattern;

constructing a transmissive light field phase shift mask (PSM) having various phase shifted

> regions according to the performed assignments and opaque regions for patterning said second gate level layout pattern portion, said PSM comprising said gate level layout pattern, said second gate level layout pattern portion including said zero degree phase shift regions and said 180 degree phase shift regions said opaque regions of said transmissive light field PSM corresponding to said Intersection regions and to said opaque regions of said first gate level layout pattern portion; and
>
> aligning said PSM in a stepper and exposing a positive resist on said semiconductor wafer with a light source directed through said transmissive light field PSM by focusing with said lens system the said light source which transmits through said PSM onto said positive resist on said wafer."

Claim 1 of auxiliary request 1 appends the following text to the penultimate paragraph of claim 1 of the main request:

> "providing on said PSM a compensating transition phase shift region around and contiguous to said 180 degree phase shift regions and between said 180 degree phase shift regions and said zero phase regions, said compensating transition phase shift region being contiguous with the entire periphery of said 180 degree phase area except for the region where said 180 degree phase area overlaps a region having said opaque region thereon; and"

Claim 1 of auxiliary request 4 inserts the following additional paragraph into claim 1 of auxiliary request 1 before the final paragraph:

> "wherein the step of providing on said phase shift mask a compensation transition phase shift region around and contiguous to said 180 degree phase shift regions includes the step of determining the physical distance between adjoining 180 degree phase shift regions and combining adjoining 180 degree phase shift regions together if the said physical distance is less than the minimum distance required to provide said transition phase shift region around each said 180 degree phase shift region, and".

V. The following prior art documents *inter alia* were cited in the examination procedure:

D2: Physics Today, July 1993, pp. 28 to 36

D4: SPIE, vol. 1927, 1993, "Proceedings of the SPIE, Optical/Laser Microlithography VI", pp. 2 to 16

D5: SPIE, vol. 1927, 1993, "Proceedings of the SPIE, Optical/Laser Microlithography VI", pp. 182 to 189

VI. The appellant applicant argued essentially as follows:

- It was the aim of the present invention to allow the layout of phase shifting masks to be executed in an automated manner by a computer. Owing to the complexity of the layout, the design could run into conflicting requirements where, for one feature, a

mask area should have been of one phase, while for another feature, it should have been of the other phase. Previously the user had to "manually" interfere with the layout design and rearrange the respective phase areas in an appropriate manner. Because of the highest possible minimization of the phase shift regions in the method of the present application, the automation process using computer automated layout designs was greatly enhanced, since situations where phase conflicts irresolvable by computer occurred were largely, if not completely, eliminated.

- None of the prior art documents on file disclosed or even suggested to limit the phase shift to the regions of the gate level layout overlying the active region layout. The need for the development of an automated tool for designing phase shift masks was moreover explicitly mentioned in document D4.

- As to auxiliary request 1, document D4 did not disclose the use of a compensating transition phase shift region between the zero degree and the 180 degree phase shift regions on the same photolithographic mask on which the zero and 180 degree regions were formed.

Reasons for the Decision

1. The appeal is admissible.

2. *Main request – Inventive step*

2.1 The present application relates to a lithography method using alternating phase shift masks in order to improve the pattern resolution. The lithography method according to claim 1 essentially consists in identifying the intersection regions between the gate level layout pattern and the active region layout pattern of an integrated circuit and in assigning respectively a zero and a 180 degree phase shift region to each one of the long sides of these intersection regions, so that the alternating phase shift method is applied only to the actual gates of the transistors. The remaining parts of the gate level layout pattern, ie the interconnect and the contact regions, are patterned using a conventional photolithographic mask.

2.2 According to the application numerous phase shift conflicts can be avoided and free space is made available for the compensating transition phase shift regions by restricting the phase shift regions only to the actual gates of the transistors. This makes it possible to implement the mask design process automatically (column 3, lines 6 to 28 of the published application)

2.3 Document D4 discloses a comparison of various phase shift strategies and the application of phase shift masks (PSM) to 0.35 μm application specific circuit design. The importance of an automatic tool for generating the phase shift level is emphasised in connection with the light field/positive resist version of the phase shift method. For this purpose a data preparation tool named CAPSI (Computer Aided Phase

Shift level generation Imec) that relies on the following working principle is succinctly described: (1) determining whether transparent regions are critical or not, ie whether they are adjacent to high-resolution Cr lines that cannot be printed in a reliable way with a conventional mask; (2) if transparent regions are indeed considered to be critical, they are alternatingly assigned a phase of 0° or 180° in a subsequent step; (3) finally, the 180° assigned rectangles are merged into one phase shift level. Input is required from the lithographer whether or not a critical dimension (CD) can be printed with a conventional mask. The lithographer may for example decide that phase shifting should be used for all features smaller than or equal to 0.5 µm. The program will then not consider features larger than 0.5 µm (pages 7 to 8).

2.4 The lithography method of claim 1 differs from the method disclosed in document D4 in that the phase shift method is applied only to the actual gates of the transistors, ie the so-called Intersection regions.

The objective technical problem corresponds therefore to the one disclosed in the application (see point 2.2 above).

2.5 When designing a PSM the skilled person is confronted with several new constraints which are not present in the design of a conventional photolithographic mask. He cannot therefore merely adopt the conventional mask design methods, but has to analyze carefully how the new constraints influence the mask design. In particular, he has to decide for each circuit which

regions are critical in the sense disclosed in document D4, ie whether they really require a phase shift mask to be patterned in a reliable way. For a circuit comprising gates and active regions, ie a circuit comprising field effect transistors, the critical regions are limited to the actual gates of the transistors, since a precise linewidth control is only required in the actual gates in order to obtain a reliable performance of the transistors (see eg D5, page 182, Introduction). The interconnects and the contact regions on the other hand do not require such linewidth control and would indeed benefit from a wider layout, as this reduces their electrical resistance.

Contrary to the appellant's contention that the prior art did not suggest limiting the phase shift masks to regions where they were necessary, the statement made in document D4 that "if transparent regions are *indeed* considered to be critical" (page 7) shows that the analysis for deciding which regions are considered critical should be done carefully for each circuit design.

2.6 From the above considerations the board concludes that the skilled person would identify the actual gates of the transistors with the critical regions mentioned in document D4 and would introduce alternating phase regions only along both sides of the actual gate regions. The lithography method of claim 1 of the main request therefore does not involve an inventive step in the sense of Article 56 EPC.

3. *Auxiliary requests 1 and 4 – Inventive step*

3.1 As compared to the method of claim 1 of the main request, the method of claim 1 of auxiliary request 1 (AR1) further specifies that:

(a) a compensating transition phase shift region is provided at the boundaries of 180° regions which are not adjacent to an opaque region, ie at the 0°/180° boundary.

Further to the method of claim 1 of AR1, the method of claim 1 of auxiliary request 4 (AR4) specifies that:

(b) if the distance between two 180° regions is less than the minimum distance required for providing a compensation transition region around each 180° region, then these 180° regions are combined into a single 180° region.

3.2 Document D4 discloses that multiple phase shift masks containing regions with intermediate phases between 0° and 180° were used for solving the phase conflict arising at the 0°/180° boundaries which produce unwanted opaque lines on the photoresist (page 8; Figure 10). The transition region on the mask having intermediate phase levels has the purpose of avoiding the formation of the unwanted opaque lines at the 0°/180° boundaries (D2, page 32, right hand column, "Making the Mask").

3.3 The board is not persuaded by the argument put forward by the appellant applicant's representative at the oral proceedings, that the intermediate phase regions

disclosed in document D4 were formed in different masks and that the photoresist was exposed subsequently with each one of these masks, as it is a requirement for interference to occur that the light be substantially coherent. A subsequent exposure cannot produce interference with a previous exposure.

The board considers therefore that transition phase shift regions, ie feature (a), were already employed in the prior art documents D2 and D4 for the same purpose as in the application.

3.4 Feature (b), ie merging two adjacent 180° phase regions when there is not enough room for providing intermediate phase regions between them, is a matter of common sense and even hinted at in document D4, where it is stated that the assigned 180° phase rectangles are merged into one phase shift level. The provision of a transition phase shift region is only required at the boundaries of zero and 180° regions. If the distance separating two 180° phase shift regions is so small that it cannot accommodate two transition phase shift regions and an intermediate zero phase region, then the possibility arises that only the two intermediate phase shift regions can be accommodated. However, two contiguous transition phase shift regions do not serve any sensible purpose and can therefore be dispensed with. The remaining two 180° phase shift regions would therefore be merged together.

3.5 The board judges therefore that features (a) and (b) are obvious measures for the skilled person having regard to documents D2 or D4. Hence the lithography

methods of claim 1 of AR1 and AR4 do not involve an inventive step in the sense of Article 56 EPC.

Order

For these reasons it is decided that:

The appeal is dismissed.

Registrar Chair

S. Sánchez Chiquero G. Eliasson