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Datasheet for the decision of 10 July 2014

Case Number: T 1708/09 - 3.4.03

Application Number: 04013786.1

Publication Number: 1605492

IPC: H01J37/244, H01J37/28, G01R31/305

Language of the proceedings: EN

Title of invention:
Charged particle beam device with retarding field analyzer

Applicant:
ICT Integrated Circuit Testing Gesellschaft für Halbleiterprüftechnik mbH

Headword:

Relevant legal provisions:
EPC 1973 Art. 56

Keyword:
Inventive step - main request (yes)

Decisions cited:
T 0002/83

Catchword:

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Case Number: T 1708/09 - 3.4.03

D E C I S I O N
of Technical Board of Appeal 3.4.03
of 10 July 2014

Appellant: (Applicant)	ICT Integrated Circuit Testing Gesellschaft für Halbleiterprüftechnik mbH Ammerthalstrasse 20a 85551 Heimstetten (DE)
Representative:	Zimmermann, Gerd Heinrich Zimmermann & Partner Postfach 330 920 80069 München (DE)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 5 March 2009 refusing European patent application No. 04013786.1 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman	T. Bokor
Members:	V. L. P. Frank
	S. Ward

Summary of Facts and Submissions

I. This is an appeal against the refusal of European patent application No. 04 013 786 for lack of inventive step (Article 56 EPC 1973).

II. At the oral proceedings before the board the appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of the main request filed at the oral proceedings or on the basis of one of the 1st to 12th auxiliary requests. The auxiliary requests correspond respectively to the main and 1st to 11th auxiliary requests filed with the statement of grounds of appeal.

The main request consists of the following documents:

Claims: 1 to 25 filed at the oral proceedings;
Description: pages 1-9, 9a, 10-14, 14a, 14b and 15-45 filed at the oral proceedings;
Figures: sheets 1/14 to 14/14, as originally filed.

III. The independent claims of the main request read as follows:

"1. A retarding field analyzer (1, 50) for detecting charged particles (2,105) comprising:
- at least one filter grid electrode (4) connectable to a first voltage (V1);
- an entrance grid electrode (10);
- a charged particle detector (8) positioned to detect the charged particles (2,105) that have passed through the entrance grid electrode (10) and the filter grid electrode (4); and
- at least one further electrode element (170, 170a, 170b, 170aa,170ab, 170bb, 170bb, 122, 122a, 122b,

152, 152a, 152b), the at least one further electrode element being one cylindrically shaped jacket, wherein the at least one further electrode element is made of high-ohmic material to provide for a high ohmic resistance between the entrance grid electrode (10) and the at least one filter grid electrode (4) with the high-ohmic material having a resistivity between 10^9 Ω cm to 10^{11} Ω cm; wherein the at least one further electrode element is adapted such that the potential on the surface increases or decreases linearly in the direction of the optical axis when a second voltage (V2) is applied to the entrance grid electrode."

"22. A method of inspecting a specimen (102) by means of a primary charged particle beam (104) generated by a charged particle beam device (100) according to any one of the claims 14-21, with the steps:

- providing the specimen (102) for inspection by the primary charged particle (104) beam;
- applying a tube voltage (VT) to the beam tube element (130);
- applying a first voltage (V1) to the at least one filter grid electrode (4);
- directing the primary charged particle beam onto the specimen to generate secondary charged particles (105) emitted from the specimen (102);
- electrically shielding the secondary charged particles (2; 105) from the beam tube element (130), with the potential of the at least one further electrode element increasing or decreasing linearly in the direction of the optical axis when a second voltage (V2) is applied to the entrance grid electrode;
- scanning the primary charged particle beam (104) across a region of the specimen (102); and

- detecting the secondary charged particles (2, 105) that have passed through the at least one filter grid electrode (4) as a function of the scanning position by the primary charged particle beam (104)."

The auxiliary requests are of no relevance for this decision.

IV. The following documents are mentioned in this decision:

D5: Patent Abstracts of Japan, vol 013, no 356 (E-803) & JP 01 117260 A

D17: US 4 658 137 A

V. The examining division essentially argued that:

- Document D5 disclosed a retarding field analyser for detecting charged particles having all the features of the analyser of claim 1 except the specified resistivity range of the high-ohmic material. According to the applicant, the feature of a resistivity between 10^9 and 10^{11} Ω cm was a selection invention to avoid breakdowns/flashovers and excess charge gathering. This particular resistivity range was however obvious when adapting the analyser of D5 to a particular set-up with different size or beam current. The skilled person would choose the required resistivity by using the generally known rules of electrical engineering for approximately choosing parameters like geometry and beam current. The particular choice of resistivity as claimed in claim 1 depended on the system in a straightforward way and did not involve an inventive step.

- The applicant's argument that the positioning of rings one after the other as in D5 would lead to discontinuities and to a potential on the surface of the jacket that did not increase or decrease continuously in the direction of the optical axis was not found convincing, since due to the current flowing across the cylindrical jacket in D5 and Ohm's law, the electric potential would increase or decrease continuously even if the jacket was fabricated from discrete elements. The true shape of the potential was an approximation (consisting of more or less linear, continuously joined segments) of the curve shown on the right hand side of fig. 2a of D5. D5 therefore disclosed a potential on the surface of the jacket that increased or decreased continuously in the direction of the optical axis.

VI. The appellant argued essentially as follows:

- The subject-matter of the present application was directed at a retarding field analyzer. Retarding field analyzers were used to discriminate charged particles according to their kinetic energy with high energy resolution. This was achieved by providing a well-defined electrical potential barrier which rejected charged particles with energy levels too low to overcome the potential barrier. Charged particles that had a sufficient energy overcame the potential barrier and were detected by a charged particle detector. The present retarding field analyzer was particularly used in charged particle beam devices for inspecting specimens. The need for highly constant and exact fields in the retarding field region became more and more an issue in view of the ongoing reduction of the sizes of the structures on the specimens to be examined. Even small deviations from the optimal homogenous fields led to a reduced error detection of the analyzer and/ or made the analyzer useless for certain applications.

- Document D5 did not disclose that the further electrode element was a cylindrically shaped jacket made of a high-ohmic material. In D5 a multitude of insulator rings was provided between the grids. D5 explicitly highlighted the fact that the resistivities of the insulator rings differed from each other so that a hemispherical electrical field was generated. A stack of differing rings did not constitute a jacket and would not allow a homogenous field to be achieved. The electrical field adjacent to the positions where the rings touched each other would not be continuous. The local presence of irregularities and resistance jumps along the inner surface of the ring stack did not lead to a continuous field in the sense of the present application allowing high quality detection.

- D5 also did not disclose the claimed range of resistivity. This range was however not an arbitrarily chosen range but the result of continued research. In operation, ie with a charged particle beam traversing the analyzer, a quasi-stationary state of the high-ohmic material was desired with the charge density on the surface being constant. This resulted in a continuous potential drop along the further electrode element. If the resistivity was too small, electrical breakdowns and flashovers could occur. If the resistivity was too high, excess charge accumulated on the electrode, leading to the formation of an undesired potential on the electrode. A resistivity of the claimed magnitude allowed a perfect field and the possibility to operate the device continuously since no charging effects occurred.

- Document D17 disclosed an electrode formed by a tube coated with a resistive material. It was however very difficult to homogeneously coat the interior of a tube of small dimensions. The resulting electric field was thus not as homogeneous as desired, since thickness variations of the coating were unavoidable.

- Thus, for a person skilled in the art there would not be any motivation to take the teaching of D5 and replace the arrangement of rings - that was explicitly disclosed in order to achieve the object of D5 - by a cylinder jacket with a resistivity in the claimed range resulting in a continuous field. There was also no motivation to replace the electrode element of D17 by a single cylindrical jacket of high-resistive material.

Reasons for the Decision

1. The appeal is admissible.

2. *Main request - Amendments*

2.1 Claim 1 was amended to state that the further electrode element was made of, instead of merely comprising, high-ohmic material having a resistivity between 10^9 Ω cm to 10^{11} Ω cm. This is disclosed on page 35, lines 7-11 of the original description.

Claim 1 was further amended to state that the further electrode element was adapted such that the potential on the surface increases or decreases linearly in the direction of the optical axis. This is disclosed on page 36, lines 23-26 of the original description.

2.2 The description was adapted to the amended claims and to acknowledge the relevant prior art.

2.3 The board is thus satisfied that the requirements of Article 123(2) EPC are fulfilled.

3. Main request - Inventive step

3.1 The present invention discloses a retarding field analyzer for detecting charged particles. Such analyzers are used *inter alia* for analyzing integrated circuits by voltage or material contrast measurements. For this purpose the required electric field resolution is of some few eV and the required spatial resolution is of the order of tenths of nanometers. Hence a very precise electric retarding field needs to be created within the analyzer. However, as size shrinks the ratio of the stray/retarding electric field becomes more and more important (present application, pages 1-6).

3.2 Document D5 discloses a retarding field analyzer comprising an entrance grid electrode G20, a filter grid electrode G30, charged particle detectors 34 and a further electrode element 37. The further electrode element is a resistor cylinder formed by lamination of a plurality of ring shaped resistors of varying resistivities. The application of a DC voltage between grids G20 and G30 generates a hemispherical potential which allows a voltage measurement precision equivalent to the case of a hemispherical grid to be obtained (Abstract, figures 1 and 2).

3.3 The appellant argued that the retarding field analyzer of claim 1 differed from the one disclosed in document D5 in that:

(a) the further electrode element was a cylindrically shaped jacket,
(b) it was made of a high-ohmic material having a resistivity between 10^9 Ω cm to 10^{11} Ω cm, and
(c) it was adapted such that the potential on the surface increases or decreases linearly in the direction of the optical axis when a second voltage is applied to the entrance grid electrode

3.4 In document D5 however the resistor cylinder 37 is stated to be *"formed via the lamination of a plurality ring-shaped resistors"* (Abstract, "Constitution"). The board thus considers that the resistor cylinder of D5 is a cylindrically shaped jacket, since lamination is the technique of manufacturing a material in multiple layers, so that the composite material has specific material properties that are the result of combining the different layers, and since a laminate is usually permanently assembled by heat, pressure, welding, or adhesives, making it thus a single body.

3.5 Hence the board considers that the analyzer of claim 1 differs from the one disclosed in D5 by features (b) and (c) mentioned above.

3.6 Features (b) and (c), ie the selected resistivity range and the linear relationship of the potential, allow the stray electric field regions 41a and 41b within the further electrode element to be reduced, as can be seen from figure 8 of the present application (see also page 36, last paragraph).

The objective technical problem addressed by the invention can thus be seen in improving the spatial and energy resolution of a retarding field analyzer.

3.7 Document D5 does not disclose the resistivities of the ring forming the further electrode element 37. It only discloses schematically that the rings have decreasing or increasing resistances (figure 2(a)), leading thus to a non-linear potential 41 along the optical axis (figure 2(b)). This non-linear potential curve is exactly the aim of D5, namely to obtain a hemispherical potential distribution.

3.8 The board considers that the skilled person would not be led by document D5 to modify the potential curve 41 to achieve something inherently different, namely a linear variation. Furthermore, there is no motivation in D5 to select the specific resistivity range specified in claim 1, also considering the fact that standard materials have resistivities outside this claimed range.

3.9 The examining division also mentioned document D17 as a possible starting point for assessing inventive step.

This document discloses a retarding field analyzer comprising an entrance grid electrode 27, filter grid electrodes 28, a charged particle detector 35 and a further electrode element 25, 29. The further electrode element is formed by a tube 25 coated on the inside with a resistive coating 29. The further electrode element is stated to provide the required electrostatic field for retarding the secondary electrons so that they approach the filter grid at substantially the same speeds as when they were emitted by the sample (Figure 2; column 5, lines 6-44).

3.10 Hence the analyzer of claim 1 differs from the one disclosed in D17 in that the further electrode element is made of a high-ohmic material having a resistivity between 10^9 Ω cm to 10^{11} Ω cm, since the coated tube 29 of D17 can be considered a cylindrically shaped jacket and the potential on its surface increases or decreases linearly in the direction of the optical axis when a potential is applied to the entrance grid electrode.

3.11 The appellant argued that it was very difficult to homogeneously coat the inside of an insulating tube with a resistive coating if the dimensional constraints of achieving an analyzer with high spatial resolution were taken into account, since this meant that the dimensions of the further electrode had to be small. Furthermore, it was necessary that the coating had a uniform thickness so that the potential drop along the optical axis be as linear as possible.

3.12 Hence the objective technical problem addressed by the invention when starting from D17 is the same as when starting from D5, namely improving the spatial and energy resolution of a retarding field analyzer.

3.13 The board considers that there is no motivation for the skilled person to replace the coated tube of D17 by a cylinder made of high-ohmic material. In particular, the teaching of D5, in which a cylinder made of high-ohmic material was used, points in another direction, namely to achieve a non-linear potential drop. In summary, the board considers that the replacement in an electrode element of a coated insulating tube by an homogeneous cylinder of a material with the required resistivity is not obvious in view of the prior art available.

3.14 It appears that the present case is a good example of what has been identified as the *"could-would approach"* for assessing inventive step (T 2/83, OJ 1984, 265; "Case Law of the Boards of Appeal", I.D.5; "Guidelines for Examination", G-VII, 5.4, June 2012 Ed). There is no doubt that the skilled person could have provided an electrode element of a high-ohmic material having a resistivity within the claimed range, as the specific materials were available to him. There is however no motivation in the prior art that would have led the skilled person to do so. The technical effect achieved by making the electrode element from this material, ie a higher electric field homogeneity, becomes apparent once the decision to do so has been taken. Recognizing this, however, is based on hindsight.

3.15 The board judges for these reasons that the retarding field analyzer of claim 1 involves an inventive step within the meaning of Article 56 EPC 1973.

3.16 As method claim 22 is directed to a method of inspecting a specimen with a charged beam device that employs the retarding field analyzer of claim 1, it inevitably involves an inventive step, since using something new and inventive cannot be obvious.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the Examining Division with the order to grant a patent on the basis of:

claims 1 to 25 of the main request filed in oral proceedings before the Board;
description pages 1 to 9, 9a, 10 to 14, 14a, 14b and 15 to 45 filed in oral proceedings before the Board;
drawing sheets 1/14 to 14/14, as originally filed.

The Registrar: The Chairman:

S. Sánchez Chiquero T. Bokor

Decision electronically authenticated