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D E C I S I O N
of 28 June 2001

Case Number: T 0859/98 - 3.5.2

Application Number: 90308259.2

Publication Number: 0412690

IPC: H01J 37/317

Language of the proceedings: EN

Title of invention:
Device manufacture involving lithographic processing

Patentee:
AT&T Corp.

Opponent:
Nikon Corporation

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (no)"

Decisions cited:
-

Catchword:
-

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Case Number: T 0859/98 - 3.5.2

D E C I S I O N
of the Technical Board of Appeal 3.5.2
of 28 June 2001

Appellant: (Opponent)
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Decision under appeal: **Interlocutory decision of the Opposition Division of the European Patent Office posted 26 June 1998 concerning maintenance of European patent No. 0 412 690 in amended form.**

Composition of the Board:

Chairman: W. J. L. Wheeler
Members: R. G. O'Connell
B. J. Schachenmann

Summary of Facts and Submissions

I. The opponent as sole appellant contests the interlocutory decision of the opposition division that European patent 412 690 as amended met the requirements of the EPC.

II. The following prior art documents, which were among those considered in the first instance proceedings, featured in the appeal proceedings:

E1: Springer Series in Optical Sciences, vol 43: X-Ray Microscopy, Editors G. Schmahl and D. Rudolph, Berlin 1984, pages 119 to 128,
Article by H. W. P Koops and J. Grob,
Submicron Lithography by Demagnifying Electron-Beam Projection;

E19: Transmission Electron Microscopy, Ludwig Reimer, Springer Verlag, 1984, pages 112 to 113 and 186 to 195;

P15: J. Vac. Sci. Technol., volume 12, No. 6
Nov/Dec 1975, pages 1135 to 1140,
Article by M. B. Heritage,
Electron-projection microfabrication system.

III. In the decision under appeal the opposition division found that the subject-matter of claim 1 as amended was new and inventive over the closest prior art E1. In the statement of grounds of appeal the appellant opponent contested the permissibility of the amendments to claim 1 and the finding of novelty and non-obviousness.

IV. In a reasoned communication accompanying the summons to oral proceedings, the board identified the function of the diaphragm aperture referred to in E1 at 13.5 as a critical point in relation to the issues of novelty and inventive step in the appeal and expressed the board's provisional opinion that this diaphragm aperture was the space frequency filter referred to in the same paragraph and was also the space frequency filter diaphragm referred to at the end of 13.1, and that the board was accordingly not persuaded by the reasoning in the decision under appeal towards the end of point 4.3 which appeared to regard these different names as referring to different things.

V. At the oral proceedings held before the board on 28 June 2001, which the appellant opponent, as foreshadowed in his letter of 26 March 2001, did not attend, the board indicated that it had doubts concerning the permissibility under Article 84 and 123(2) EPC of the amendments made before the opposition division, as they appeared to introduce a functional feature which had not been disclosed in the application as originally filed. The respondent proprietor stated there was no intention to change the substance of the subject-matter claimed and he was therefore prepared to revert to the form of claims in the published patent; cf the respondent's single request below.

VI. Independent claim 1 of the patent is worded as follows:

"1. Method for device fabrication comprising at least one fabrication step including a lithographic delineation step, said delineation step using a lens system (46,49) and comprising projection of patterned radiation to produce a pattern image (9) on a body

comprising a device under fabrication in order to selectively process such pattern image during the said fabrication step, in which a mask is illuminated by radiation from a radiation source (41) to result in said patterned radiation,
CHARACTERIZED IN THAT
the path of said patterned radiation includes a back focal plane filter (47) defined as positioned on the back focal plane or on some equivalent conjugate plane of such lens system, said filter including two types of filter regions the first of which (48) is more transparent to said patterned radiation than the second so that the first filter region/regions define the pass portion of said filter, said filter serving to block transmission of a part of said patterned radiation dependent upon degree of scatter as imposed by said mask, wherein said mask is either a transmission mask (43) or a reflection mask (2')."

Claims 2 to 20 are dependent on claim 1.

VII. The appellant opponent argued essentially as follows:

(i) The patent specification clearly described the concept of the opposed patent as being the application of a principle well known from microscopy to lithography, ie the illumination of an object (specimen in microscopy, mask in lithography) that contained regions of varying scattering capability, and the subsequent use of a back focal plane filter to provide contrast between the regions of varying scattering capability. In other words **the core of the disclosed concept was to apply the principle of scattering contrast imaging known from**

microscopy to lithography.

(ii) On the other hand the patent specification did not describe how much of the radiation scattered by the mask reached the focal plane, neither qualitatively nor quantitatively. In fact, the patent specification made absolutely no mention of energy that passed the mask but did not reach the filter. Consequently, there was also no information or data on how the amount of scattered radiation interacted with the presence or absence of the back focal plane filter to thereby influence the contrast in the image plane.

(iii) E1 disclosed the use of a scattering mask. The sentence at 13.5 in E1: "Electrons passing the original are scattered in the heavy metal lines of the replica but can penetrate the carbon foil with less interaction" meant that the foil mask had two regions having a different degree of scattering. Electrons incident on the carbon foil could penetrate and electrons incident on the heavy metal lines were scattered and formed a diffraction pattern at a focal plane. A diaphragm set at the focal plane acted as a space frequency filter and stopped all higher orders of scattered waves. The electrons which penetrated the carbon foil could pass the space frequency filter and the electrons in all higher orders of scattered waves were stopped by the space frequency filter so that contrast was formed.

(iv) The foil mask used in E1, a carbon replica foil

with a platinum pattern thereon was a textbook example of a scattering mask, cf E19, page 193. There was no doubt that E1 showed the use of a scattering mask.

VIII. The respondent proprietor's arguments can be summarised as follows:

(i) E1 (Koops et al), although the only relevant document, was not as close as might appear at first sight. In particular, section 13.5 of the document which, when read with knowledge of the invention of the opposed patent, might give the impression of teaching the use of a scattering mask in the sense of claim 1 of the latter was, in fact, concerned with something else, namely a solution to the so-called stencil problem. The latter referred to the need to provide webs in a lithographic mask to support disconnected portions of the mask, eg an annulus-defining central disk, and the ensuing need to prevent the images of these webs appearing as an artefact in the desired lithographic pattern, eg by a second exposure step. Koops taught the elimination of support webs by "the application of self-supporting foil masters in a reducing image projection system having a contrast aperture stop in the entrance pupil." In the experiment described in E1, Koops used a carbon replica grating shadowed with platinum as lithographic mask. Although this eliminated the webs it gave rise to a different artefact: electrons penetrating the carbon foil gave rise to a diffraction pattern which would reduce contrast in the lithographic pattern image.

Hence Koops taught, as the second part of his solution, the further step of using a contrast aperture to stop the first and higher orders of this diffraction pattern. It was solely to obviate this latter source of loss of contrast that Koops taught the use of the aperture, which he also referred to as a space frequency filter. This was summarised at E1, page 121, third paragraph. However Koops explained the contrast produced by his aperture as being formed "in the reducing image projector like in a CTEM (conventional transmission electron microscope) as scattering absorption contrast." Here Koops was explaining the contrast enhancing action of his aperture as being **analogous** to that of the scattering absorption contrast aperture which would be familiar to the skilled reader from its notorious use in CTEM. It was important to note that the loss of contrast that Koops was concerned with did not originate in the mask proper, but in the foil carrier therefor. The skilled reader would appreciate that Koops, writing in 1983 would be referring to an absorption mask, which was the standard mask before the priority date of 1989 of the opposed patent. Thus the passage : "Electrons passing the original are scattered in the heavy metal lines of the replica but can penetrate the carbon foil with less interaction. The diffracted waves however are focused by the field lens to form a source image at the entrance pupil." was not a discussion of what the mask did, but rather drew attention to those of the incident electrons which were not absorbed by the mask and which penetrated the

carbon foil and which had the potential to reduce contrast in the desired lithographic pattern as a result of diffraction in the foil.

(ii) The interpretation of E1 put forward in the board's communication according to which Koops worked the invention of the opposed patent as a bonus effect to his primary aim of suppressing the carbon foil diffraction pattern was not tenable. Scattering absorption contrast as achieved in the opposed patent was based on a systematic analysis and was not achievable by accident. Thus the platinum lines of the mask would need to be specially selected to produce the required result. In this respect the conclusion reached by Mr Mamoru Nakasuji in his statement filed in the course of the opposition proceedings with the opponent's letter dated 5 September 1997 that the Pt mask used by Koops was not an absorbing mask because the data given in E1 implied a thickness in the range 40 to 70 nm, whereas a thickness of at least 900 nm would be required to prevent penetration by 40 kV electrons, was not well founded. Full absorption was not the aim. In fact wide angle scattering was irrelevant; one only needed to go down to a thickness where no electrons entered the optical system. The affidavits filed in the opposition proceedings showed that in the 40 to 70 nm thickness range, indeed above 10 nm there were no electrons scattered at a sufficiently small angle to enter the optical system. Koops taught nothing about the Pt thickness; there was no discussion of absorption or scattering. He was concerned only with diffraction by the carbon

foil.

(iii) The invention of the opposed patent was a method and Koops did not teach the working of the invention claimed in the opposed patent. The latter required that very distinct measures be employed which were not taught in E1.

IX. The appellant opponent requested that:

- the decision under appeal be set aside and that the patent be revoked.

X. The respondent proprietor requested that:

- the decision under appeal be set aside and that the patent be maintained as amended on the basis of:

Claims: 1 to 20;

Description: columns 1 to 28 and

Drawings: Figures 1 to 8;

of the patent specification, with the insert filed with the letter of 31 October 2000 to go after line 13 of column 8 of the patent specification.

Reasons for the Decision

1. The appeal is admissible.

2. The crucial issues in this appeal are novelty and inventive step of claim 1 over E1.

3. *Terminology*

In the relevant art the term "absorption" in relation to a beam of radiation or matter incident on a body means, in a first, wide, sense, the removal of radiation or matter from the beam giving rise to an attenuation in the transmitted beam relative to the incident beam. The radiation or matter lost from the beam is either scattered, ie deflected to emerge in a direction different from that of the incident and transmitted beams, giving rise to so-called scattering absorption; or it is absorbed in the material of the body, the latter being "absorption" in a second, $narrower sense. Generally it will be clear from the context which meaning applies, but, to avoid ambiguity the board will sometimes mark the relevant sense by the use of a subscript, thus: beam absorption$_1$ = material (body) absorption$_2$ + scattering absorption$_3$.

4. *Novelty*

4.1 The patent relates generally to a method for device fabrication including a lithographic delineation step and comprising projection of patterned radiation on a body in which a mask is illuminated by radiation to result in said patterned radiation. In the main embodiment described in the patent specification the radiation is a beam of electrons, ie the technology known as electron projection lithography (EPL). Without prejudice to the generality of claim 1, the board's assessment of novelty and inventive step in relation to the claim, will be, like the description in the patent,

in terms of EPL. By the same token the discussion will relate to the transmission as opposed to the reflection variant; cf patent specification, column 8, lines 35 to 42. As acknowledged in the opposed patent at column 6, line 35 to column 7, line 33, EPL was an actively pursued technology in the 1970s which "for the most part, made use of absorbing masks" (column 7, lines 3 and 4). Prior art document P15 is representative of this art and the precharacterising portion of claim 1 of the opposed patent corresponds thereto.

4.2 As noted in the patent, column 7, lines 25 to 33, "required thick absorption regions, in conjunction with the (incomplete) nature of the absorption phenomenon itself, gives rise to electrons escaping from the edge of the absorbing region. Associated resolution limitation is a consequence of such electrons being improperly transmitted/blocked due to either of two mechanisms. Electrons as initially scattered or as misdirected due to reduced energy are improperly captured or excluded."

4.3 Thus the patent appears to acknowledge that one of the known shortcomings of EPL using absorption$_2$ masks was that scattered electrons, which ideally should have been absorbed in the material of the mask, were able to travel down the optical system and be registered in the image pattern as transmitted electrons, thus causing what should have been a black region of the image to appear grey, ie reducing contrast.

4.4 The patent continues (column 7, lines 34 to 55):

"The history of conventional transmission electron microscopy is relevant to this discussion. Constant

demand toward resolution of finer and finer features has been attended by design alterations. A consequence is very thin specimens as well as high accelerating voltages - both to expedite resolution of such small features. Both are attended by lowered absorption, by a degree of absorption inadequate to resolve features, and just as important, inadequate for replicating a grey scale needed for resolving detail within "blocking" regions. The now familiar solution to the problem is in a mode of electron microscopy known as "Scattering Contrast Transmission Electron Microscopy". This mode relies upon imaging as based upon the degree to which electrons experience scatter upon transmission through the specimen. Such imaging is dependent upon an apertured back focal plane filter. The principle of the operation is well known - unscattered electrons are selectively transmitted or blocked depending upon placement of the aperture. Replication of adequate grey scale is due to dependence of transmission on scattering angle."

4.5 The solution specified in claim 1 of the opposed patent to the problem of loss of contrast in EPL is to use the back focal plane filtering technique known from CTEM to block the scattered electrons, a technique which is commonly referred to in the CTEM art as scattering absorption$_3$ contrast. Thus at column 20, line 52 the patent states:

"The single feature common to all aspects of the invention is selective passage of transmitted lithographic energy as dependent on angle of scatter introduced by the mask." (The terms "lithographic" and "mask" mark the application to EPL). The fact that it is a direct transfer of the technique from the field of

CTEM to that of EPL is confirmed at column 21, lines 20 to 25 the patent, where it is stated:

"Design principles for the filter are known (and are regularly used in scattering contrast transmission electron microscopy). Design, largely in terms of aperture diameter, is simply with the objective of selective passage of energy based on scattering angle, however, with a view to the inventive objectives."

4.6 It is common ground that E1 is the most relevant prior art document, that it relates to EPL and that it discloses an arrangement employing a back focal plane aperture to enhance lithographic pattern contrast by stopping (absorbing) scattered electrons, although the parties disagree as to the origin of these scattered electrons.

4.7 The respondent proprietor maintains that the mask described in E1 is of the type which was standard in EPL technology as practised in 1983, ie an absorption$_2$ mask involving negligible scattering and that the function of the back focal plane aperture in the arrangement of E1 is purely the suppression of the first and higher orders of the diffraction pattern produced by the carbon foil membrane carrier of the self-supporting, ie webless, mask. On this interpretation of the disclosure of E1, the fabrication method of claim 1 is distinguished from E1 by the feature that in accordance with the claimed method the part of the patterned radiation blocked by the filter is "dependent upon degree of scatter as imposed by said mask", whereas in E1 the scatter is not imposed by the lithographic mask proper but by its ancillary support structure, ie the carbon foil membrane. Thus, according

to the respondent proprietor's interpretation there is no teaching in E1 of the designing of the filter to match the radiation patterning of the lithographic mask and hence the claimed method is neither worked in E1 nor suggested thereby.

4.8 On the appellant opponent's interpretation of the prior art document E1, however, the latter does indeed disclose the use of a scattering, as opposed to an absorption mask. In the statement of grounds of appeal, bottom of page 21, the appellant drew attention to the concluding sentence in the two-paragraph summary at the head of the document E1 (page 119, last sentence of the second paragraph): "We show that foil masks render sufficient scattering absorption contrast to be employed as an original in projection systems."

He has also pointed out that the carbon replica shadowed with platinum used in E1 is a textbook example of a scattering contrast structure (cf E19, pages 193 and 194).

Further the appellant has established convincingly that the term "scattering absorption contrast" is widely used in the art to describe what is referred to as "scattering contrast" in the patent specification, ie both terms refer to the undisputedly well-known technique for providing adequate contrast in a conventional transmission electron microscope; compare E1, page 126, paragraph 13.5 "Contrast is formed in the reducing image projector like in a CTEM as scattering absorption contrast" and the patent specification, column 7, lines 44 to 55 (cf point 4.4 above.)

The appellant construes the sentence at 13.5 in E1:

"Electrons passing the original are scattered in the heavy metal lines of the replica but can penetrate the carbon foil with less interaction." as meaning that the foil mask has two regions having a different degree of scattering: electrons incident to the carbon foil can penetrate and electrons incident to the heavy metal lines are scattered and form a diffraction pattern at a focal plane. He further asserts (statement of grounds of appeal, middle of page 18) that "the skilled person also knows well that there is absolutely no difference in terms of effect in the imaging process for diffraction or scattering."

4.9 Thus the parties have essentially opposite views about the fate of the electrons "scattered in the heavy metal" in the EPL system described in E1. For the respondent proprietor they are not captured by the electron optics; to that extent they behave like absorbed$_2$ electrons and the focal plane aperture or space frequency filter of E1 has no effect on them. For the appellant opponent they are the main source of potential loss of contrast and the main purpose of the focal plane aperture stop is to absorb them, together with those diffracted by the carbon foil, so as to enhance contrast exactly as in a conventional transmission electron microscope.

On the latter reading E1 would destroy the novelty of claim 1 of the opposed patent.

4.10 The board's interpretation of the disclosure of E1 is intermediate between the opposing views of the parties in that it agrees with the respondent proprietor that E1 appears to teach that the main purpose of the focal plane aperture stop or space frequency filter is to

suppress the diffraction pattern produced by electrons coherently scattered in the carbon foil carrier of the webless stencil mask, but the board is not entirely persuaded that E1 can be read as teaching that the electrons "scattered in the heavy metal" are not stopped by the space frequency filter to any significant degree. There is, in the judgement of the board, sufficient doubt about the latter point as to make it impossible to conclude that E1 clearly and convincingly discloses the use of a method of device fabrication using a scattering mask in the sense of claim 1. The board therefore regards the subject-matter of claim 1 as new having regard to the available prior art.

5. *Inventive step*

5.1 Starting from E1 as closest prior art, the relevant objective technical problem is to improve the resolution and depth of focus achievable in EPL; cf patent specification column 8, lines 17 to 21 and column 17, lines 31 to 34. As is notorious in the art, the straightforward way of achieving this is by the use of higher energy electrons with a shorter de Broglie wavelength, so that the problem is effectively to adapt the fabrication method of E1 to enable electrons having an energy significantly greater than the 40 keV used therein to be employed. Formulating such a problem is a routine activity for the person skilled in the art, the parameters constraining the performance of EPL systems

being well understood as is clear from the discussion in the introduction to the opposed patent. In particular, it is well understood that higher energy electrons incident on an absorption$_2$ mask give rise to potentially destructive heat dissipation.

5.2 In the judgement of the board, the skilled person addressing the problem referred to immediately above would study E1 since it is specifically concerned with fabricating nanometre structures by EPL; cf E1, first paragraph. He would not fail to notice the fact that the foil replica masks proposed in E1 as a solution to the stencil problem "can withstand higher power densities than bulk stencils" (E1, page 121, lines 15 and 16) since this suggests the possibility of using higher energy electrons. In particular he would notice that the use of low absorption$_2$ foil masks is linked in E1 to the application in EPL of the well known scattering absorption contrast technique - thin specimens scattering electrons which are then intercepted by a space frequency filter aperture in the focal plane - used in conventional transmission electron microscopy.

5.3 The board is mindful of the great danger of being unfair to an inventor in reading a document such as E1 with hindsight in the light of the disclosure in the opposed patent. While bearing this risk very much in mind, the board nevertheless judges that the skilled person reading such statements as: "The use of foil masks and the contrast mechanism in the demagnifying projection system is discussed. We show that foil masks render sufficient scattering absorption contrast to be employed as an original in projection systems." in the introductory summary of E1 and a subsequent perusal in

E1 of the technique by which this is achieved, would find at least a decisive suggestion in the direction of choosing a lithographic mask which patterns the incident beam at least to a significant degree by scattering electrons which are absorbed in a space frequency filter at the focal plane.

5.4 In coming to this conclusion the board is influenced by the fact that the invention as claimed in claim 1 of the opposed patent is a broad concept admittedly based on the transfer of the scattering absorption contrast technique from conventional transmission electron microscopy to EPL, as prefigured in the description of the patent specification at column 20, lines 52 to 55: "The single feature common to all aspects of the invention is selective passage of transmitted lithographic energy as dependent on angle of scatter introduced by the mask."

5.5 It is undisputed that E1 teaches the application of the conventional transmission electron microscope technique of scattering absorption contrast to the field of EPL at least as far as the mask foil carrier is concerned, so that the bridge from conventional transmission electron microscopy to EPL is undeniably established. It is also a fact that E1 refers to electrons being scattered by the heavy metal lines, ie the lithographic mask proper. While it remains true, as noted above in the discussion of novelty, that the discussion in E1 of the action of the focal plane aperture does not explicitly state that the latter is lithographically active in stopping these electrons scattered by the heavy metal the step that remains for the skilled person to take is one that he would take, guided by his aim of using high energy electrons which cannot be

absorbed$_2$ without damage in the mask.

5.6 This conclusion is reinforced by the consideration, that the structure of the mask described at 13.5 in E1 ("A foil mask is prepared as a replica of a surface relief using standard transmission electron microscopy preparation techniques. From photoresist line patterns recorded by laser interferometry, carbon grating replicas were fabricated. They are shadowed with platinum...") corresponds to text-book examples of structures for use in provide scattering absorption contrast imaging (cf E 19, pages 193 and 194).

6. Hence, having regard to E1 and common general knowledge in the art, the subject-matter of claim 1 of the patent is not to be considered as involving an inventive step within the meaning of Article 56 EPC.

7. The board concludes therefore that the grounds for opposition mentioned in Article 100 EPC prejudice the maintenance of the patent.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The patent is revoked.

The Registrar: The Chairman:

U. Bultmann W. J. L. Wheeler