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# D E C I S I O N
## of 19 May 1999

**Case Number:** 0376/95 - 3.4.2

**Application Number:** 85903153.6

**Publication Number:** 0183827

**IPC:** G03F 7/20, G02B 27/00

**Language of the proceedings:** EN

**Title of invention:**
DEEP-UV LITHOGRAPHY

**Patentee:**
AT&T Corp.

**Opponent:**
Canon Kabushiki Kaisha

**Headword:**
-

**Relevant legal provisions:**
EPC Art. 100(b)

**Keyword:**
"Sufficiency of disclosure (no)"

**Decisions cited:**
T 0585/92

**Catchword:**
-

Europäisches Patentamt | European Patent Office | Office européen des brevets

Beschwerdekammern | Boards of Appeal | Chambres de recours

**Case Number:** T 0376/95 - 3.4.2

**D E C I S I O N**
**of the Technical Board of Appeal 3.4.2**
**of 19 May 1999**

**Appellant:** (Proprietor of the patent)
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**Decision under appeal:** **Decision of the Opposition Division of the European Patent Office posted 8 March 1995 revoking European patent No. 0 183 827 pursuant to Article 102(1) EPC.**

**Composition of the Board:**

**Chairman:** E. Turrini
**Members:** R. Zottmann
M. Lewenton

## Summary of Facts and Submissions

I. The Appellant (Patentee) lodged an appeal against the decision of the Opposition Division on the revocation of the patent No. 0 183 827 with the application No. 85 903 153.6.

The opposition was based merely on Article 100 b) EPC.

The Opposition Division held that the ground of opposition laid down in Article 100 b) EPC prejudiced the maintenance of the patent.

II. Of the documents cited during the opposition proceedings and the opposition appeal proceedings, the following will be cited in this appeal decision:

D1: SPIE, vol. 237, 1980, International Lens Design Conference (OSA), pp. 310-320 (Glatzel: "New lenses for microlithography");

D2: SPIE, vol. 237, 1980, International Lens Design Conference (OSA), pp. 216-221 (Hoogland: "Systematics of photographic lens types");

D3: SPIE, vol. 135, Developments in Semiconductor Microlithography III (1978), pp. 77-82 (Buzawa, Phillips: "Ultraviolet objectives for submicron photolithography");

D4: SPIE, vol. 237, 1980, International Lens Design Conference (OSA), pp. 329-336 (Phillips, Buzawa: "High resolution lens system for submicron photolithography");

D5: SPIE, vol. 811, Opt. Microlith. Technol. for IC Fabric. and Inspect., 1987, pp. 22-30 (Braat: "Quality of microlithographic projection lenses");

D9: TROPEL catalogue, allegedly published in 1977 (see first affidavit of Phillips, section 7.), cover sheet, Table of Contents, pages 1-13 and a final sheet (numbered by the Appellant as pages 8-23);

D11: Opt. Eng., vol. 15, no. 2 (1976), pages 90-94 (Hopkins, Buzawa: "Optics for laser scanning");

D12: Reprint from: *Laser Focus Magazine*, September 1980, pages 82-85; reprinted pages numbered by the Appellant as pages 25-27 (Buzawa: "Lens system for laser scanners");

D13: J. Opt. Soc. Am. **39** (1949), pages 719-723 (Grey, Lee: "A new series of microscope objectives: I. Catadioptic newtonian systems").

III. Oral proceedings were held at the end of which the Appellant requested that the decision under appeal be set aside and the patent be maintained as granted.

The Respondent (Opponent) requested that the appeal be dismissed.

IV. The independent claims read as follows:

"1. A deep U.V lithography system comprising a laser (12) which inherently emits relatively wide bandwidth electromagnetic radiation, and a lens assembly (108) in optical communication with said laser, said lens assembly

exhibiting acceptably low chromatic aberration to the laser radiation impinged upon the assembly, CHARACTERISED IN THAT the lens assembly is made of fused silica, which fused silica would inherently exhibit unacceptably high chromatic aberration to the relatively wide bandwidth radiation inherently emitted by said laser, and in that means (54) are provided for sufficiently narrowing the bandwidth of the radiation emanating from said laser and impinging upon the fused silica so as to achieve acceptably low chromatic aberration."

"8. A method of achieving acceptably low chromatic aberration of laser radiation transmitted via a lens assembly in an optical lithography system, the laser inherently emitting relatively wide bandwidth electromagnetic radiation, CHARACTERISED IN THAT the lens assembly is made of fused silica which would inherently exhibit unacceptably high chromatic aberration to the relatively wide bandwidth radiation inherently emitted by the laser, and in that the method further comprises narrowing the bandwidth of the radiation emanating from the laser and impinging upon the lens assembly to a sufficient extent so as to achieve acceptably low chromatic aberration."

The remaining claims are dependent on claims 1 or 8.

V. The Appellant's arguing is summarized as follows:

Claim 1 contains two inventions, namely one concerning the means for narrowing the bandwidth of the light emanating from the laser and the other concerning the lens assembly made of fused silica. The EPC does not demand that two inventions be disclosed in one patent

specification and thus the specification need not contain detailed informations how to design a suitable lens system.

Claim 1 does not contain restrictions to the lens system requiring an amazing quality standard. Nevertheless high quality was possible in 1984 since only monochromatic aberrations must be corrected. According to D11 and D12, design of lens systems is simplified significantly if it is to be used at only one wavelength. In 1984, 1.25 µm resolution was the state of the art and not submicron resolution.

When a lens was to be designed, first the skilled person has to start from a known lens design. In this field there were no textbooks showing suitable lens designs. There was no shortage of starting points (for details, see paragraphs 2 to 7 of section 2.6 below). Every lens designer had to have a repertoire of lens designs for his work. When designing a new lens system he had to look through said fund of lens designs and to select an appropriate starting point lens system. The schematic lens systems shown in D3 and D4 were sufficient for this purpose since exact optical data were not necessary for the skilled lens designer. Moreover, said lens system was sold before the priority date, see D4 page 335 paragraphs 3 and 4. As far as the microscope objective of D13 is concerned, it is submitted that reflective layers were usual in the art.

A suitable starting lens system design had then to be changed by a computer program to a lens system suitable for the purpose of the patent-in-suit. In 1984, such a program was available and did not require intervention by

the designer. Moreover, low levels of intervention were routine in the lens design process. Correcting aberrations other than chromatic aberration was a process that was encountered routinely and frequently in the design of lenses.

The appealed decision came very shortly after the lengthy submissions by the Respondent and before the Appellant had an opportunity to respond to those new issues.

VI. The Respondent's arguing is summarized as follows:

As to the "two inventions' argument" of the Appellant: The lens system of the patent-in-suit is an essential part of claim 1 and thus the specification must contain sufficient informations how to design an appropriate lens assembly or the skilled person should have been able to develop such a lens assembly.

The patent-in-suit deals with a high quality lens system and thus very high quality properties must be achieved.

The lens systems proposed by the Appellant as starting points were unsuitable for the purpose; either details were not or too late made available to the public or the lens systems differ too much from the final design. When starting from one of the lens systems proposed by the Appellant (see section 2.6 below), the skilled person was not able to arrive at a suitable all-fused-silica lens assembly without an excessive amount of trial and error.

After revocation of the patent by the Opposition Division on the basis of Article 100 b) EPC, the burden of proof that the sufficiency requirements of the patent are met

has shifted to the Appellant.

## Reasons for the Decision

1. The appeal is admissible.

2. *Sufficiency*

2.1 Irrespective of the question raised by the Appellant whether each of the independent claims contains one inventive concept or two such concepts, it is necessary for the purpose of Article 100 b) EPC that the specification of the patent-in-suit provides sufficient information enabling the average skilled person to realize the subject-matter defined by such a claim, that is a subject-matter with all features of such a claim. Moreover, in the present case narrowing of the bandwith of the laser light and the fused silica lens assembly are linked to such an extent that both are mutually dependent and thus necessary to realize the subject-matters of the independent claims.

2.2 According to claim 1, the lens assembly is made of fused silica and forms part of a deep ultraviolet lithography system, and, according to the introductory paragraph of the patent specification, the invention relates to apparatus for achieving short-wavelength optical lithography, in particular at 248.4 nm, said apparatus being adapted for fabricating high-quality fine-line semiconductor devices, for example for very large scale integration (VLSI) chips processing. It was not disputed by the parties that the lens assembly (108) which is schematically shown in Fig. 2 as a simple biconvex lens

108 only symbolizes a plurality of lens elements forming a lens system of very high standard. In the opinion of the Board, such a lens assembly is amongst the highest quality of all the lens systems in the world, see also the requirements for such an assembly as laid down in the following subsection 2.3.

2.3 The technical problem underlying the solution according to claim 1 is, therefore, to provide a lithographic system which is designed for use in the deep ultraviolet wavelength range, in particular at 248.4 nm; the solution of this problem requires a lens assembly made exclusively from fused silica and having very high quality, in particular high resolution and low distortion (see col. 1 lines 10-27 and 38-40, col. 3 lines 15-28 and 46-52, col. 4 lines 30-31 and col. 10 lines 50-51).

In view of the fact that prior art provides or at least demands a resolution of ultraviolet lens assemblies well below 1 µm, rather below 0.5 µm (D1, page 317: 0.9 µm; D3, page 77 last but one paragraph: " ... technological advances ... have now progressed to the point where 0.5 to 0.6 micron lines are now a definite requirement." and last paragraph of page 81: " ... 0.5 micron lines can be achieved."; D4, last paragraph: " ... it is reasonable to expect ... 0.5 microns or less."), the all-fused-silica lens assembly must be properly corrected for all different kinds of monochromatic lens aberrations such that patterns of sub-micron dimensions can be projected onto the surface of resist-coated wafer. An increased depth of focus is required, for wafers are not flat but have steps. The object and image field sizes are large (see e. g. the abstract and page 316 last paragraph of D1 and D4 Table 1) and have to be flat.

Such a high resolution in combination with said particular object and image dimensions can only be achieved if the lens assembly is accurately corrected for monochromatic aberrations, such as Petzval curvature and fifth order distortion. The difficulty in producing a lens system of the required quality is mainly caused by the correction of monochromatic aberrations and not by that of chromatic aberrations. Reference is made to D1 where also chromatic aberration has to be corrected and where it is nevertheless stressed that the fifth-order distortion remains the limiting aberration of lenses for microlithography (see e. g. page 319 third paragraph). Documents D11 and D12, which were introduced by the Appellant, refer to lens systems for laser scanning which belong to a different type of lens system which e. g. do not require a large focus depth.

Designing a lens system from fused silica that meets the above-mentioned criteria and works at such a short wavelength is much more difficult than designing a multi-material lens system working at longer wavelengths. Due to the low refractive index of silica, spherical aberration increases considerably and the increased curvature needed leads to much tighter manufacturing tolerances (see e. g. D3 page 78 first half). To be able to exceed the limit of 365 nm to shorter wavelengths for microlithography lenses, Glatzel, at the end of his article in D1, comes to the conclusion that "the glass manufacturers will have to come up with new glasses or the optical designers will have to invent systems made of quartz glass and fluorite". This means that the average skilled person was confronted with considerable difficulties when trying to put into practice a suitable lens assembly.

Though also bending and spacing contribute to Petzval sum correction (see D2 page 219 at the bottom), the means used in practice to reduce the Petzval sum and thus image field curvature is to select different materials for collective and divergent elements having considerably differing refractive indices (see D1, pages 310 and 311). Restriction to only one lens material makes it thus more difficult to reduce the Petzval sum and thus image field curvature.

Furthermore, the lens assemblies designed for the long wavelength ultraviolet, e. g. for 365 nm, can still be tested at 405 nm because the axial image at this wavelength is still well corrected but those designed for 248.4 nm cannot be tested by visual inspection (see D3 page 81 paragraphs 3 and 4: "Perhaps one of the most frustrating aspects of producing these lenses is that of testing ... "). For off-axis behaviour only optical transfer function (OTF) measurements would be usable which are a poor diagnostic, i. e. they are hardly usable during the manufacturing, mounting and centring phase, but only effective for testing the completed lens assembly.

2.4 According to the attacked patent (see col. 3 lines 20-25 and 46-51), a lens assembly suitable for the lithography system of claim 1 was not available to the public at the priority date. This has not been disputed by the Appellant.

The disclosure concerning the lens assembly in the specification of the attacked patent is very scant. According to the description (see col. 4 lines 27-36), the lens assembly has only to meet some conditions in

view of the use of the assembly for high-resolution lithography. The all-fused-silica lens assembly should be developed for operation with a laser light the bandwidth of the wavelength of said light being reduced to less than about 0.01 nm so as to be free of chromatic aberrations. To meet this condition, a pulsed excimer laser emitting light at 284.8 nm is combined with a bandwidth-narrowing assembly. Hence, the patent teaches that said lens assembly should provide the desired resolution, preferably for said wavelength. However, said specification does not disclose any details concerning the design parameters (number of and type of lenses, e. g. use of aspheric lenses, lens radii, axial distances etc.) nor does it provide any specific embodiment of a lens assembly.

2.5 Moreover, the Appellant did not furnish evidence for the average skilled person's ability to design such a lens assembly, e. g. by presenting suitable basic handbooks or textbooks.

2.6 In the absence of such an evidence and any specific teaching from the patent in respect of the lens design providing the necessary properties set out in section 2.3 above, the Appellant should at least have furnished evidence that the average skilled person was able to realize said lens assembly on the basis of the teachings of the prior art (it remains the question as to whether the cited prior art documents represent common general knowledge of the average skilled person).

The Appellant indicated that the following lens assemblies could be used as starting points:

(1) a multi-material lithographic lens assembly designed at Tropel in 1977 for use with a 365 nm (Hg-i-line) source mentioned in D9; apparently, a schematic of said lens is shown in Figs. 1 and 2 of D3 and Fig. 1 of D4 (see e. g. the first affidavit of Fischer, section 22., the second affidavit of Phillips, section 15., and the fourth affidavit of Phillips, section 6.);

(2) a multi-material lithographic lens assembly designed at Tropel in 1985 for use with a 365 nm (Hg-i-line) source (a schematic of said lens is shown in EXHIBIT 3 of the first affidavit of Phillips);

(3) the "Braat lens", a multi-material lithographic lens assembly published in D5 for use with a 405 nm (Hg-h-line) source; a schematic of said lens is shown in Fig. 1, the optical data are contained in Table 1;

(4) in the second affidavit of Phillips, section 3., the Appellant mentions that, as a starting point all-fused-silica lenses were used as UV collimators;

(5) single glass lenses were used in special UV microscope objectives; as an example of the latter, he mentioned the objective with fluorite refractive elements shown in Fig. 3 of D13;

(6) every lens designer has a "repertoire" of lens systems containing a lens system appropriate as starting point.

The publications D3 and D4 where the lens assembly (1) is disclosed in schematic drawings do not provide the numerical data concerning e. g. the lens radii, spacings, glass materials, cements. The catalogue pages according to D9 do not show any lens assembly or any geometric data of the lens system. The Appellant alleged that such a lens assembly was sold before the priority date and referred to D4 page 335 ("A 40 mm lens has been installed in a Jade Step and Repeat camera at Ferranti, Ltd. in England ... A 26 mm lens has been installed in a Mann camera at Hansom Air Force Base ... "). However, he did not indicate and provide evidence of the conditions, such as secrecy and accessibility, of the sold lenses and the optical data of the sold lenses.

Since (2) was designed only in 1985 and (3) was disclosed only in 1987, they are inappropriate as starting points for demonstrating sufficiency of the patent.

As to (4) and (5), the Appellant has not furnished details of the lens (4) and the ("converted") lens assemblies developed from (4) and (5). Moreover, the lens system (5)/D13 refers to a microscope objective working by a combination of reflection (using mirrors) and refraction whereas projection lenses work by refraction only. The object and image fields of microscopes are much smaller than those of microlithography lenses.

The Appellant has not provided evidence for his allegation that said "every skilled" person has a

"repertoire" (6) of lens systems and has not indicated which lens systems are in any case comprised by it. Moreover, it is, apparently, not a published starting point and cannot be characterized as common general knowledge.

Thus none of the lens systems (1) to (6) would have provided a lens designer of average skill with a suitable starting point.

2.7 In the absence of an appropriate starting point, it is not necessary to deal with the question as to whether the average skilled person was able to carry out the further steps necessary to convert the multi-material lens systems to an all-fused-silica lens assembly with the required properties.

2.8 In the proceedings before the Opposition Division, the burden of proving that the objections raised under Article 100 b) EPC have been substantiated lay with the Opponent. However, after revocation of the patent by the Opposition Division, the burden shifted to the Appellant (Patentee), who must demonstrate on appeal that the reasons for revoking the patent were not sound, that is that the Opposition Division's decision was wrong as to the merits (following decision T 0585/92, OJ EPO 1996, 129, which was mentioned also by the Respondent during the oral proceedings). The Appellant did not succeed in demonstrating that the attacked decision was deficient as to its substance.

2.9 Since sufficient disclosure of the aspect of the patent defined by claim 1 is to be denied, it is not necessary to deal with sufficiency of the disclosure of the aspects

of the patent defined by the remaining claims, in particular as defined by independent claim 8.

3. The Appellant alleged that the appealed decision came so early that he had no opportunity to respond to those new issues. However, said decision came more than four months after despatch of the submissions to the Appellant, which is considered as being time enough to respond to those issues or at least to request that the decision of the Division be postponed for some time.

## Order

## For these reasons, it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

P. Martorana E. Turrini