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Datasheet for the decision of 5 December 2024

Case Number: T 2220/21 - 3.4.03

Application Number: 14156445.0

Publication Number: 2772930

IPC: H01J37/04, H01J37/305

Language of the proceedings: EN

Title of invention:
Focused ion beam low kv enhancement

Patent Proprietor:
FEI Company

Opponent:
Carl Zeiss Microscopy GmbH

Headword:

Relevant legal provisions:
EPC Art. 100(a), 54(1)
RPBA 2020 Art. 13(1)

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It can be changed at any time and without notic

Keyword:

Grounds for opposition - main request (patent as granted) - Novelty (no)
Amendment to appeal case - late filed auxiliary requests - amendments overcome issues raised (no), give rise to new issues (yes)

Decisions cited:

Catchword:

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Case Number: T 2220/21 - 3.4.03

D E C I S I O N
of Technical Board of Appeal 3.4.03
of 5 December 2024

Appellant: (Patent Proprietor)	FEI Company 5350 NE Dawson Creek Drive Hillsboro, OR 97124-5793 (US)
Representative:	Stellbrink & Partner Patentanwälte mbB Widenmayerstrasse 10 80538 München (DE)
Respondent: (Opponent)	Carl Zeiss Microscopy GmbH Carl-Zeiss-Promenade 10 07745 Jena (DE)
Representative:	Glawe, Delfs, Moll Partnerschaft mbB von Patent- und Rechtsanwälten Postfach 13 03 91 20103 Hamburg (DE)
Decision under appeal:	**Decision of the Opposition Division of the European Patent Office posted on 12 October 2021 revoking European patent No. 2772930 pursuant to Article 101(3)(b) EPC.**

Composition of the Board:

Chair	T. Häusser
Members:	M. Papastefanou
	T. Bokor

Summary of Facts and Submissions

I. The appeal of the patent proprietor is against the decision of the opposition division revoking European patent No. 2 772 930 B1.

II. Reference is made to the following document, cited in the decision under appeal:

E1: Michael Rauscher: *Development of an Advanced Low Energy Focused Ion Beam System Based on Immersion Optics*. Dissertation, Universität Tübingen, 2006; XP 055650597.

III. The opposition was based on the grounds of lack of novelty and inventive step (Article 100(a) EPC) and added subject-matter (Article 100(c) EPC).

In the decision under appeal, the opposition division concluded, among others, that the subject-matter of claim 1 of the patent as granted was not new over E1.

IV. At the end of the oral proceedings before the board, the appellant ("proprietor") requested that the decision under appeal be set aside and that the patent be maintained as granted, as its main request, or on the basis of one of auxiliary requests 1 or 2 filed with letter dated 23 February 2024. Auxiliary requests 3 to 7, filed with the same letter, were withdrawn during the oral proceedings before the board.

The respondent ("opponent") requested that the appeal be dismissed.

V. Claim 1 of the **patent as granted** is worded as follows (labelling of features as used in the opposition procedure):

(a) An apparatus comprising:
(b) a source (102) of a primary ion beam for use on a target (106);
(c1) and a focused ion beam column (101) having a middle section (120)
(c2) that can be biased to a high negative voltage allowing the beam to move at higher potential than the final beam energy inside that section of the column,
(d) and comprises an electrode (112) of a first lens,
(e) an electrode (113) of a second lens,
(f) and one or more electrostatic scanning deflectors,
(g) wherein the deflector electrodes (135) are referenced to the middle section bias negative voltage characterized in that
(h) said middle section has two usage modes,
(i) a first mode wherein the middle section can be grounded
(j) and a second mode wherein the middle section is biased to a negative high voltage.

VI. Claim 1 of **auxiliary request 1** is worded as follows (difference with respect to claim 1 of the main request marked by the board):

An apparatus comprising:
a source (102) of a primary ion beam for use on a target (106); and
a focused ion beam column (101) having a middle section (120) that can be biased to a high negative voltage allowing the beam to move at higher potential than the final beam energy inside that section of the column, and comprises an electrode (112) of a first

lens, an electrode (113) of a second lens, and one or more electrostatic scanning deflectors, wherein the deflector electrodes (135) are referenced to the middle section bias negative voltage,
characterized in that said one or more electrostatic scanning deflectors are comprised in a scan octupole;
said middle section has two usage modes, a first mode wherein the middle section can be grounded and a second mode wherein the middle section is biased to a negative high voltage;
said apparatus further comprises a column isolation valve (132); and
said middle section comprises a beam defining aperture (130), a differential pumping aperture (131) of the column isolation valve (132), steering poles (133), blanking plates and a faraday cup (134).

VII. Claim 1 of **auxiliary request 2** has the following wording (difference with respect to claim 1 of the main request marked by the board):

An apparatus comprising:
a source (102) of a primary ion beam for use on a target (106); and
a focused ion beam column (101) having a middle section (120) that can be biased to a high negative voltage allowing the beam to move at higher potential than the final beam energy inside that section of the column, and ~~comprises~~ is made up of an electrode (112) of a first lens, an electrode (113) of a second lens, a beam defining aperture (130), a differential pumping aperture (131) of a column isolation valve (132), steering poles (133), blanking plates and a faraday cup (134) and one or more electrostatic scanning deflectors, wherein the deflector electrodes (135) are referenced to the middle section bias negative voltage,

~~characterised in that~~ wherein said one or more electrostatic scanning deflectors are comprised in a scan octupole (135);
wherein said middle section has two usage modes, a first mode wherein the middle section can be grounded and a second mode wherein the middle section is biased to a negative high voltage; and
wherein said apparatus further comprises the column isolation valve (132).

VIII. The parties' arguments can be summarised as follows:

On the novelty of claim 1 of the main request

The **proprietor** argued that it was not permissible in an objection of lack of novelty to combine different disclosures even if from the same document. In any case, section 4.3.3 of E1 (see below) taught away from a focused ion beam apparatus as defined in claim 1 as granted. Claim 1 of the main request was thus new.

The **opponent**, following the line of the opposition division, argued that E1 taught three alternative implementations for the placement of the deflectors with respect to the objective lens. Each of those implementations corresponded to a different embodiment, and one of those anticipated the claimed apparatus. Claim 1 of the main request was thus not new.

On the admittance of auxiliary requests 1 and 2

The **proprietor** argued that these requests contained amendments overcoming the lack of clarity objection of the opposition division against auxiliary request 6A-1 filed before the opposition division. The current auxiliary requests 1 and 2 were based on that request.

They moreover addressed the opponent's objections concerning added subject-matter raised in the reply to the appeal. They did not introduce any new subject-matter and should thus be admitted by the board.

The **opponent** argued that the requests were filed late and not properly substantiated. Moreover, they did not *prima facie* overcome the lack of clarity objection by the opposition division and gave rise to new objections of added subject-matter. They should not be admitted.

Reasons for the Decision

1. The invention

1.1 The claimed invention relates to a focused ion beam system. Such systems direct a beam of charged particles (ions) onto a target. Focused ion beam systems are used in a wide variety of applications, such as electron microscopy, lithography, ion milling, material deposition and dopant implantation.

1.2 In general, in such a system ions emitted from an ion source are aligned in a beam and directed onto a target surface. The system comprises an apparatus (column) comprising lenses and deflectors to align (focus) and direct the beam.

1.3 In the construction and operation of such systems, there are partially conflicting requirements.

1.3.1 On the one hand, a high-energy beam (e.g. 5 keV) is easier to direct and achieves good spot sizes (i.e. high resolution). Such a high-energy beam, however, risks to damage the target. On the other hand, a low energy beam may not damage the target but makes it more

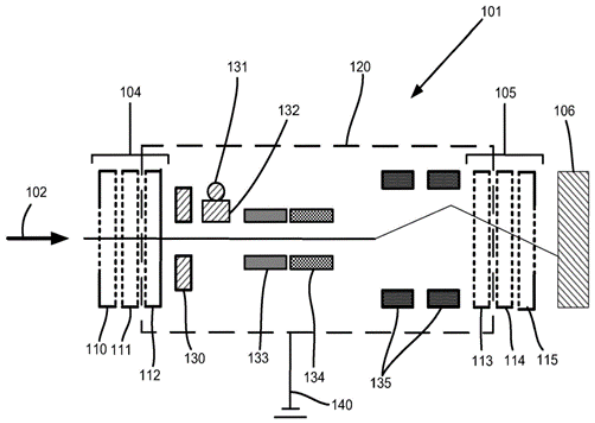
difficult to achieve high resolution.

1.3.2 Other conflicting requirements relate to the position of the lenses and the deflectors. Given that the ions in the beam have the same charge, there are repulsive forces which tend to "push" them away from each other. Lenses are used to keep the beam focused ("tight") so that it can hit the target at one spot. In general, such a lens should be placed as close as possible to the target, so that the beam remains focused when it hits the target. In order to direct the beam onto the various spots on the target, however, electronic deflectors are used. If the deflectors are placed after the lens (i.e. between the lens and the target) then the distance from the lens to the target ("working distance") is increased, which is detrimental to keeping a focused beam hitting the target. If the deflectors are placed before the lens (upstream in the beam direction), the working distance can be smaller. However, in such a case, the beam is deflected before it passes through the lens, which is detrimental to its focusing, as it will not necessarily pass through the centre of the lens (see paragraphs [0003] to [0012] of the patent).

1.4 The claimed invention seeks to find a compromise between these conflicting requirements by proposing a focused ion beam column in which the middle section is biased to a higher potential than the final beam energy. This lets the ions "travel" within the middle section at high energy, which reduces the effect of the repelling forces and allows the beam to remain focused and achieve high resolutions. This also allows the deflectors to be placed before (upstream of) the lens, reducing the working distance (see paragraphs [0015],

[0016], and [0024] to [0026] of the patent).

1.5 Figure 2 of the patent shows an embodiment according to claim 1 of the main request:

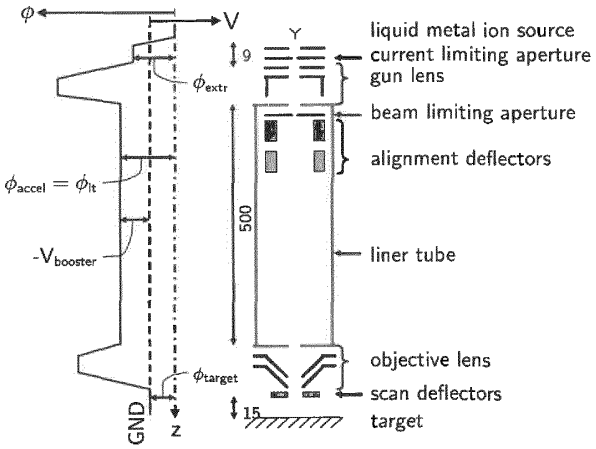


The ion beam (102) coming from the source, travels through the focused ion beam column (101) to hit a target (106). The column comprises a middle section (120) comprising an electrode (112) of a first lens (104), an electrode (113) of a second lens (105) and electrostatic deflectors (135), which direct the beam to scan the target. The middle section (120) is biased to a high negative voltage, and so are all the parts that are placed within, including the deflectors (135).

2. Main request (patent as granted), novelty (Articles 100(a), 52(1) and 54(1) EPC)

2.1 The opposition division considered that E1 disclosed all the features of claim 1 of the main request.

2.1.1 Reference is made in particular to Figure 4.9 (page 43) of E1:



It is common ground that E1 discloses features (a) to (e) and (h) to (j) of claim 1 of the main request.

As it can be seen in the figure (note that in this figure the beam travels from top to bottom), the scan deflectors ("electrostatic scanning deflectors" in claim 1 of the main request) of the focused ion beam column are placed after the objective lens (i.e. downstream in the beam's direction). Hence, they are outside the liner tube ("middle section" in the claim) and not "referenced" to the middle section negative voltage. Features (f) and (g) of claim 1 are thus not disclosed in Figure 4.9.

2.1.2 In the decision under appeal, the opposition division referred to section 4.3.3 of E1 (starting on page 40). This section discusses different possible positions of the scan deflectors, namely upstream of the lens, inside the liner tube (i.e. within the middle section as in claim 1 of the main request), downstream of the lens (as in Figure 4.9) or in-lens, i.e. within the electrodes of the objective lens.

2.1.3 The relevant part of this section reads as follows (underlining by the board):

"As discussed previously a small working distance is clearly advantageous in order to keep aberrations and hence the overall probe size small. In a typical high energy focused ion beam system the liner tube is grounded and any deflection elements are hence operated with respect to ground potential. Dynamic beam scanning for image acquisition may thus be realised by using a double stage deflection arrangement upstream of the objective lens without compromising the working distance. However, with the intermediate lens space set on high potential the implementation of such a deflection system may be more difficult. Apart from problems associated with electronic control and supply at fast pixel rates there is still the task of mechanical setup of an (ideally) eight-fold split and insulated liner tube. Obviously, the use of a single stage post-lens deflector downstream of the objective lens circumvents some of these problems although clearly at the cost of an increased working distance. Alternatively, a single stage in-lens deflector employing a split final objective lens electrode may be used. With this arrangement the deflector is operated with respect to ground (as in the case of post-lens deflection) while not affecting the working distance. Furthermore the deflection sensitivity is higher than in the pre-lens deflection arrangement (assuming FFLV-R mode operation) as the beam is retarded to the final landing energy within the last electrode".

2.1.4 The opposition division held that each alternative placement for the deflectors described in this section constituted a different embodiment, in combination with the rest of the features of the column as shown in Figure 4.9. E1 thus disclosed an embodiment which anticipated the apparatus of claim 1 of the main request (see point 3.2.3 of the Reasons for the

impugned decision). The opponent argued similarly.

2.2 The proprietor argued that section 4.3.3 of E1 merely contemplated various solutions for the positioning of the scanning deflectors, but the solution presented in Figure 4.9 (with the scan deflectors after the objective lens) was the selected one, i.e. it was the only embodiment of the apparatus described in E1.

The apparatus constructed and used in E1 was described in Part III and in chapter 7 in particular (starting on page 61). As it could be seen in Figures 7.9 (page 70) and 8.1 (page 79), the apparatus corresponded to the one shown in Figure 4.9, in which the scan deflectors were placed after the lens, outside the middle section.

2.2.1 According to the proprietor, the passage in section 4.3.3 (see point 2.1.3 above) indicated that the positioning of the scan deflectors upstream of the objective lens created at least three problems, namely problems associated with the electronic control and supply at fast pixel rates and the mechanical setup of the liner tube. This indicated that additional measures had to be taken for such an implementation but neither Figure 4.9 nor any other passage of E1 described nor suggested any such measures. It could thus not be accepted that such an embodiment (i.e. with the deflectors upstream of the lens) was directly and unambiguously disclosed in E1.

2.2.2 On the contrary, the passage in section 4.3.3 indicated that placing the deflectors downstream of the lens was a straightforward and readily implemented solution, as Figure 4.9 also showed. There was no reason for the skilled person to contemplate any other embodiment of

the described apparatus.

2.2.3 The proprietor also pointed out that, in any case, it was not acceptable to combine the disclosure of section 4.3.3 with the teaching of Figure 4.9, i.e. two different disclosures, in a discussion of novelty, even if they belonged to the same document.

2.3 The board does not find the proprietor's arguments convincing.

2.3.1 As a first remark the board notes that according to established case law and practice, it is sufficient for a state of the art document to be prejudicial to novelty that the document contains an enabling disclosure anticipating the claimed subject-matter. The skilled person must be able to implement the apparatus (in this case) described in the prior art document based on the information included in the document and their common general knowledge. It is not necessary that the described apparatus is in fact manufactured or used for it to be regarded as state of the art.

2.3.2 In the present case, E1 is a dissertation relating to the development of an advanced low energy focused ion beam system based on immersion optics, as the title indicates.

Chapter 4 is part of the second part of the dissertation which presents a numerical simulation of the developed apparatus (see "II Numerical Simulation" on page 27). Chapter 4 relates to the development of the lenses of the focused ion beam column. After a presentation of the general principles (section 4.1 on page 29), a presentation of the mathematical method and the software used (section 4.2 starting on page 30),

the results of the simulation are presented in section 4.3 starting on page 36. These results relate to the gun lens (section 4.3.1) and the objective lens (4.3.2), while sections 4.3.3 and 4.3.4 examine the possibilities for in-lens scanning and lens optimisation, respectively.

Finally, section 4.3.5, where Figure 4.9 is included, presents a summary of the results and the overall system performance as obtained from the simulation.

2.3.3 Figure 4.9 and the apparatus it shows thus represent the results of the numerical simulation. As stated in section 4.3.5 (fourth sentence), *[f]or illustration purposes this envisaged mode of operation is again summarised graphically in fig. 4.9*. A similar expression is also used in the legend of the figure.

The board considers that E1 provides an enabling disclosure of the focused ion beam column presented in Figure 4.9. The parties never questioned that, either.

2.3.4 Regarding the disclosure in section 4.3.3, the board's view is that it does not exclude a placement of the scan deflectors upstream of the objective lens.

In the board's view, the "difficulties" and "problems" mentioned in relation to placing the deflectors upstream of the lens are to be understood rather as disadvantages or complications of such an implementation. Placing the deflectors upstream and downstream of the lens, were well-known in the art, as also the patent explains in its introduction (see paragraphs [0011] and [0012]). The skilled person is thus aware of both implementations and the corresponding particularities of each one. The patent

also seems to consider this common general knowledge, as no details about the technical implementation of the claimed apparatus are given.

2.3.5 The cited passage of section 4.3.3 (see point 2.1.3 above) is thus to be understood as a description of the alternative implementations for the placement of the deflectors with respect to the (objective) lens, with the advantages and disadvantages of each of them. In the board's view, the skilled person would be in a position to implement any of these alternatives based on the information provided and their common general knowledge.

2.3.6 It is also to be noted that section 4.3.3 does not provide any indication why the structure of Figure 4.9 (with the scan deflectors downstream of the lens) was chosen for the apparatus used in the experiments; neither does section 4.3.5, where the focus is on the advantages of using a liner tube on high voltage and focusing the beam in an internal acceleration mode. Hence there seems to be nothing that teaches away from any of the three alternative placements.

2.3.7 Regarding the proprietor's point concerning combining different disclosures, the board does not consider that it is applicable in this case. As stated previously, E1 describes different aspects of the focused ion beam column in different parts of the document. In order to understand a complete embodiment the skilled person is thus led to combine different parts of the document.

The possibility of combining different embodiments described in the same document may perhaps not be assumed as being the general rule in a discussion for novelty. As previously explained, however, the board

does not consider that there is a combination of embodiments in the present case. E1 describes alternative embodiments (with respect to the placement of the deflectors) of the focused ion beam apparatus and one of them anticipates the apparatus of claim 1 of the main request.

2.4 Concluding, the board agrees with the opposition division that the subject-matter of claim 1 of the patent as granted is not new over E1. The ground for opposition under Article 100(a) in combination with Articles 52(1) and 54(1) and (2) EPC prejudices, hence, the maintenance of the patent as granted.

3. Auxiliary requests 1 and 2, admittance

3.1 These requests were filed for the first time with the proprietor's letter dated 23 February 2024, after the opponent's reply to the appeal. According to the proprietor, they were based on the former auxiliary request 1, which was filed for the first time with the statement of the grounds of appeal, which in turn was based on auxiliary request 6A-1 filed during the oral proceedings before the opposition division.

3.1.1 The opposition division did not admit auxiliary request 6A-1 into the proceedings because it considered that the feature of claim 1

"*wherein the middle section contains a beam defining aperture (130), a differential pumping aperture (131) of a column isolation valve (132), steering poles (133), blanking plates and a Faraday cup (134) for beam current measurements*"

was *prima facie* not clear (Article 84 EPC) because the skilled person could not tell whether the column isolation valve (132) was part of the claimed apparatus or not (point 17 of the Reasons of the impugned decision).

3.1.2 In auxiliary request 1 the feature

said apparatus further comprises a column isolation valve (132); and

has been added before a feature essentially corresponding to the objected feature cited above.

In auxiliary request 2 the same feature has also been added but the features relating to the components included in the middle section have been rephrased and reordered. According to the proprietor, these amendments make clear in both auxiliary requests that the column isolation valve (132) is part of the claimed apparatus, overcoming the opposition division's objection.

3.2 It is uncontested that auxiliary requests 1 and 2 constitute amendments to the proprietor's appeal case which are to be admitted at the discretion of the board under Article 13(1) RPBA.

3.3 A question to be asked when contemplating admittance of the requests under Article 13(1) RPBA is whether the amendments carried out appear *prima facie* to overcome the outstanding objections without giving rise to new ones.

3.3.1 Regarding the lack of clarity objection, respective claim 1 of both requests now indeed includes the column

isolation valve (132). In both requests claim 1 defines, however, that the differential pumping aperture (131) *of the column isolation valve (132)* is part of the *middle section* (of the apparatus) while the column isolation valve is defined as part of the *apparatus* in general (but not necessarily of the middle section). The board takes the view, that this definition does not *prima facie* overcome the lack of clarity objection as it is not clear for the skilled person how the pumping aperture can be part of the middle section while the column isolation valve itself is not necessarily.

3.3.2 Claim 1 of auxiliary request 1 defines that the middle section *comprises an electrode (112) of a first lens, an electrode (113) of a second lens, and one or more electrostatic scanning deflectors* as well *as a beam defining aperture (130), a differential pumping aperture (131) of the column isolation valve (132), steering poles (133), blanking plates and a Faraday cup (134)*, i.e. all the components listed in paragraph [1023] of the originally filed description, except the booster tube (120).

In claim 1 of auxiliary request 2, the components have been reordered and the definition has been modified using the term "made up of": *a focused ion beam column (101) having a middle section (120) that ... is made up of an electrode (112) of a first lens, an electrode (113) of a second lens, a beam defining aperture (130), a differential pumping aperture (131) of a column isolation valve (132), steering poles (133), blanking plates and a faraday cup (134) and one or more electrostatic scanning deflectors*.

According to the proprietor, this amendment addressed

the opponent's objection of added subject-matter (Article 123(2) EPC) that the expression "the middle section comprises" left open that the middle section may comprise more elements, while in the application as originally filed the term "made up of" was used, excluding further elements in the middle section.

3.3.3 In the board's opinion, the expression "the middle section comprises" constitutes an unallowable intermediate generalisation as it leaves open the possibility that other, non-defined parts are included in the middle section (auxiliary request 1). This seems to be acknowledged by the proprietor, as well, see previous paragraph.

3.3.4 In auxiliary request 2 as basis for the definition "the middle section ... is made up of ..." reference is made to paragraph [1023]. That paragraph, however, does not contain any such disclosure. It rather defines that "the booster tube ... is made up of ... ". The question whether or not the terms "middle section" and "booster tube" refer to the same entity and are interchangeable was discussed during the opposition and in the appeal written procedures. The opposition division had concluded that the terms were not interchangeable and the replacement of "booster tube" with "middle section" in the expression "the booster tube ... is made up of" constituted added subject-matter (see decision under appeal, page 22, second paragraph). The board agrees.

It follows that this amendment gives *prima facie* rise to an objection of added subject-matter, as well.

3.4 Without the need to address the further objections raised by the opponent, the board concludes that the submitted amendments do not *prima facie* address the

outstanding objection of lack of clarity. Moreover, they give rise to new objections under Article 123(2) EPC because they contain subject-matter extending beyond the originally filed content of the application.

Exercising its discretion under Article 13(1) RPBA, the board decides thus not admit auxiliary requests 1 and 2 into the proceedings.

4. Since claim 1 of the patent as granted (main request) is not new and auxiliary requests 1 and 2 are not admitted, there is no allowable request on file. The appeal must therefore fail.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chair:

S. Sánchez Chiquero T. Häusser

Decision electronically authenticated