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Datasheet for the decision of 27 July 2020

Case Number: T 1994/15 - 3.4.03

Application Number: 10737667.5

Publication Number: 2441083

IPC: H01J1/15, G05D23/27

Language of the proceedings: EN

Title of invention:
METHOD AND SYSTEM FOR HEATING A TIP APEX OF A CHARGED PARTICLE SOURCE

Applicant:
Carl Zeiss Microscopy, LLC

Headword:

Relevant legal provisions:
EPC Art. 56

Keyword:
Inventive step - (yes)

Decisions cited:

Catchword:

Europäisches Patentamt
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Beschwerdekammern

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Case Number: T 1994/15 - 3.4.03

D E C I S I O N
of Technical Board of Appeal 3.4.03
of 27 July 2020

Appellant: (Applicant)	Carl Zeiss Microscopy, LLC One Zeiss Drive Thornwood, NY 10594 (US)
Representative:	Carl Zeiss AG - Patentabteilung Carl-Zeiss-Strasse 22 73447 Oberkochen (DE)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 26 May 2015 refusing European patent application No. 10737667.5 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman	G. Eliasson
Members:	A. Böhm-Pélissier
	W. Van der Eijk

Summary of Facts and Submissions

I. The appeal is against the decision of the examining division refusing the European Patent Application No. 10 737 667 on the ground that the single Request on file did not involve an inventive step within the meaning of Article 56 EPC.

II. In its decision, the Examination Division held that the skilled person starting from the teaching of D3 would consider a more sophisticated temperature control of the tip apex when reforming the tip apex in order to avoid overheating of the tip apex. Therefore, the skilled person would take into consideration the methods disclosed in D2 for controlling the temperature of the tip apex.

III. In its preliminary opinion the Board concluded that the amended Main Request as filed with the statement of grounds met the requirements of Article 56 EPC. The Appellant was requested to overcome clarity objections and to amend the description.

IV. In reply to the preliminary opinion the Appellant filed an amended claim set with letter dated 23 June 2020 and an amended description with letter dated 28 May 2020.

V. The Appellant (Applicant) requests that the decision under appeal be set aside and that a patent be granted on the basis of the Main Request:

Description pages 1-14 as filed with letter dated 28 May 2020;
Claims 1-14 as filed with letter dated 23 June 2020;
Drawings Sheets 1/6-6/6 as published.

VI. **Method Claim 1** of the Main Request reads (underlining added by the Board and corresponding to the latest amendments, Board's labelling (A) and(B)):

A method, comprising:

a) heating a tip apex (114) of a tip (112) of a charged particle source (110),

b) detecting light generated by the tip apex (114) while the tip apex (114) is heated,

c) determining whether to change the heat delivered to the tip apex (114) based on the detected light,

d) changing a temperature of the tip apex (114) based on an amount of the detected light,

characterized in that

(A) determining whether to change the heat delivered to the tip apex (114) comprises comparing an amount of the detected light to an amount of light expected to be detected at a desired temperature of the tip apex (114),

(B) and wherein determining whether to change the heat delivered to the tip apex (114) furthermore comprises determining at least two parameters, the at least two parameters are selected from the group consisting of

(a) an integral of a differential between a first temperature and a second temperature over a predetermined period of time,

(b) a derivative of the differential between the first and second temperatures,

(c) and a proportion of the differential between the first and second temperatures, the first temperature being the temperature of the tip apex (114) determined based on the detected light, and the second temperature of the tip apex (114) being the desired temperature of the tip apex (114).

System Claim 3 reads (underlining added by the Board and corresponding to the latest amendments):

A system, comprising: a charged particle source (110) comprising:
- a tip (112) having a tip apex (114), the tip apex (114) being configured to emit charged particles during use of the charged particle source (110),
- and the tip apex (114) being capable of generating light when heated, charged particle optics (1130) capable of forming a charged particle beam of charged particles emitted by the charged particle source (114) and delivering the charged particle beam (1192) to a sample (1180), a detector (170) configured to detect light generated by the tip apex (114); and a controller (180) coupled with the charged particle source (110) and the detector (170) so that the controller can control heating of the tip apex based on the light detected by the detector (170), characterized in that the controller is configured to change a heat delivered to the tip apex (114) of the charged particle source (110) by comparing a detected light amount to an amount of light expected to be detected at a desired temperature of the tip apex (114), wherein the controller is furthermore configured to determine at least two parameters for determining whether to change the heat delivered to the tip apex, the at least two parameters are selected from the group consisting of
- an integral of a differential between a first temperature and a second temperature over a predetermined period of time,
- a derivative of the differential between the first and second temperatures,
- and a proportion of the differential between the first and second temperatures, the first temperature being the temperature of the tip apex (114) determined based on the detected light, and the second temperature of the tip apex (114) being the desired temperature of the tip apex (114).

VII. Reference is made to the following documents:

D2 = ISLAM A ET AL: "Digital control system for the thermionic cathode in an electron gun", PROCEEDINGS OF THE SOUTHEAST CONFERENCE (SOUTHEASTCON), BIRMINGHAM, ALABAMA, Apr. 12 -15 1992; NEW YORK, IEEE, DOI:10.1109/SECON.1992.202423, 12 April 1992, pages 720-723, XP010057118, ISBN: 978-0-7803-0494-9

D3 = US 2007/158558 A1

DA = "The Control Handbook", Ed. William S. Levine, CRC Press, 1996, pages 198 and 199, Chapter 10.5 "PID Control", submitted by the Appellant with letter dated 28 May 2020

Reasons for the Decision

1. Admissibility of the appeal

The appeal is admissible.

2. The invention as claimed

2.1 The tip apex of an ion source of a gas filled ion microscope is heated during formation of the tip apex. The temperature of the tip apex has to be controlled within a certain range of a target temperature. When a resistive heater wire is used to heat the tip apex, it can be difficult to reliably predict how much current desirably passes through the resistive heating system, how much voltage to apply across the resistive heating system, and/or how much power to supply to the resistive heating system to ensure that the tip apex is heated within the desired range of temperatures.

2.2 It was found that the temperature of the tip apex corresponds to the amount of light emitted by the tip apex in a relatively reliable and reproducible fashion. It was found that the amount of light emitted by the tip apex can be very sensitive to temperature so that minor variations in the tip apex temperature can be detected with relatively high sensitivity.

2.3 The invention proposes a system and method designed to use the light emitted by a heated tip apex as a basis for controlling the temperature of the tip apex within a desired temperature range. Such systems and methods can be used during initial tip apex formation and/or during re-formation of a tip apex. The invention proposes as solution the characterizing portion of the independent claims (see section VI. above)

3. Amendments -Article 123(2) EPC

3.1 Present method claim 1 has been reformulated by combining the features from claims 14, 15 and 20 as originally filed. The features of claim 2 correspond to the two different modes of operation and have support in the description on original page 12, lines 8-25, page 1 line 29-30 and page 2, line 3-9.

3.2 New independent system claim 3 is based on original claims 1 and 2 to which also the features of original claim 20 have been added. Basis for this amendment is also provided on original page 4, lines 13-18. Claim 3 has the same characterising portion as claim 1.

3.3 New claim 4 corresponds to new claim 2 and is based on the same disclosure in the description as claim 2. New claim 5 corresponds to original claim 3 and new claims

6 and 7 are based on the disclosure on page 14, lines 7-11 and 13-17, respectively.

3.4 In reply to the preliminary opinion of the Board it was clarified that the integral of a differential between a first temperature and a second temperature is calculated over a predetermined period of time.

This amendment is disclosed in several passages in the description, in particular on page 9, line 8ff: "*the integral of the difference between these signals over a predetermined period of time can be taken into consideration*".

3.5 Consequently the new claim set complies with the requirements of Article 123(2) EPC.

4. Clarity - Article 84 EPC

4.1 By the addition of "over a predetermined period of time" to item (a) in Feature (B) it was clarified that the integral of a differential is calculated with respect to the time. With this amendment and from the teaching of the description the skilled person understands that also the derivative and proportion of the differential, i.e. items (b) and (c) are determined with respect to time.

4.2 The Appellant could prove by a handbook (DA) that the skilled person even without knowing the description immediately understands from the claim wording that the temperature values as claimed correspond to time dependent values. DA is a general handbook about controlling control parameters. In DA all equations given for the PID control parts depended on the variable *t*, i.e. time.

4.3 The Board agrees with the Appellant that for a person of skill in the art it is clear that nothing else but a time-dependent control system can be meant for options (a)-(c) in the claim wording although this was clarified explicitly only for option (a). The claims are therefore now clear with respect to the time-dependency of integral, derivative and differential.

4.4 Consequently, the claim set complies with the requirements of Article 84 EPC.

5. Inventive Step - Article 56 EPC

5.1 Closest prior art

The Examining Division and the Appellant have chosen D3 as closest prior art, since it has most features in common with the refused patent application. The Board agrees with this approach.

5.2 Difference

5.2.1 D3 discloses heating a tip apex (187) of a tip (186) of a charged particle source (120), detecting light generated by the tip apex while the tip apex is heated, determining whether to change the heat delivered to the tip apex based on the detected light. Regarding controlling the temperature of the tip by detecting light, D3 only discloses to switch-off the heating of the tip apex at a pre-determined time after the first appearance of light from the tip apex is detected. D3 therefore discloses that the controller can control heating of the tip apex based on the light detected by the detector, but D3 does not disclose controlling the

temperature of the tip apex. D3 rather detects by means of the photodiode a starting point for a timer for turning off both an applied potential and a heating device after 15 to 45 seconds.

5.2.2 D3 does not disclose Features (A) and (B).

5.3 **Effect**

According to the invention, controlling the heating of the tip apex is not only based on a single parameter which is deducted by comparing the detected light amount to a desired light amount, but instead is based on two parameters selected from the options (a)-(c) in Feature (B). Accordingly, at least one parameter takes into account the change between the measured temperature and the desired temperature with time. As explained in the original description starting on page 8, line 30 to page 9, line 14, overshooting or undershooting of the instant temperature of the tip apex with respect to the desired temperature can thereby be avoided.

5.4 **Problem**

The objective technical problem to be solved by the present invention can be formulated as to improve the temperature control of the tip apex, and especially to avoid an overshooting/undershooting of the temperature of the tip apex.

5.5 **Inventive step**

5.5.1 D3 does not provide any suggestion or incentive that a more sophisticated temperature control of the tip apex during reforming the tip apex could be desirable.

5.5.2 D2 discloses a method of electrically controlling the temperature of a cathode of an electron gun. D2 teaches in a first mode, the warm-up mode, a photodiode signal in a feedback control loop to adjust the heat source to reach and maintain an idle-state temperature. In this mode at start-up the photodiode signal is zero and heat is initially applied at the maximum rate. As the temperature rises, a photodiode signal begins to develop which is used in the feedback control loop to adjust the heat source to reach and maintain an idle-state temperature.

5.5.3 D2 does not provide much detail based on which algorithm the feedback control loop controls the temperature. Overshooting is avoided by choosing the idle state temperature substantially below the operational temperature where the second mode, the current mode, is used.

5.5.4 In the second mode of operation the system disclosed in D2 does not make use of the photodiode signal for controlling the temperature. Instead of a photodiode signal the voltage signal of a toroid coil is used as input signal for the control loop.

5.5.5 The Appellant argued that D2 did not disclose the use of two parameters for determining whether to change the heat delivered to the electron source disclosed in D2. In fact D2 did not disclose to use any further parameter chosen from an integral or derivative of the difference between the measured temperature and the desired temperature in this mode of operation.

5.5.6 In section "C Algorithm Description" of D2 for the current mode a time differential with respect to a temperature is mentioned in the context of the increase

in thermal energy (equation (7) and (8)). As a result the temperature of the thermionic emitter has a stable equilibrium temperature as a function of input power. This means that any deviation of the temperature from the equilibrium temperature would decay rapidly. Accordingly in this second mode of operation no temperature control of the thermionic cathode is required at all.

5.5.7 Therefore the Board agrees with the Appellant in that in D2 neither the first nor the second mode of operation teaches to use two parameters out of an integral, derivative and differential of measured temperature and the desired temperature for controlling the heat delivered to a charged particle source.

5.5.8 D2 is silent about integrating a time dependent temperature difference. D2 only teaches a control system with proportional control. In the current mode the correction signal varies in direct proportion to the deviation between the actual and desired values of the process variable, such that the output of the controller is proportional to the deviation ("error signal", equation [5]). This proportional control teaches away from a control based on integrals and derivatives of temperature difference values.

5.5.9 Also the feedback control in the first mode does not provide any teaching that temperature is controlled based on the at least two parameters mentioned above.

5.5.10 Therefore, if the skilled person starts from D3 and seeks to improve the temperature control of the tip apex by avoiding an overshooting/undershooting of the temperature of the tip apex, they would only take into consideration to control the temperature of the tip

apex according to methods as disclosed in document D2. They would therefore not be taught by D2 to implement Feature (B) into the electron microscope of D3.

5.5.11 Newly filed document DA discloses a general control method of taking -in addition to proportional control- integral and derivative of a control parameter over time into account. The skilled person would need a hint to apply the general control method to the disclosure of D3 in order to solve the objective problem mentioned above. Both D3 and D2 teach away from using a control method as described in DA.

5.5.12 Even if the skilled person combines the teachings of D3 and DA, such a combination would not lead to Feature (A), i.e. that determining whether to change the heat delivered to the tip apex comprises comparing an amount of the detected light to an amount of light expected to be detected at a desired temperature of the tip apex.

5.5.13 None of DA, D3 and D2 alone or in combination teaches to avoid an overshooting/undershooting of the temperature of the tip apex by combining a photodiode signal as input temperature signal with a two-parametric differential/integral time dependent temperature control algorithm. Therefore combining the teachings of DA, D3 and D2 does not lead to a combination of Features (A) and (B).

5.5.14 Therefore, the Board considers the subject-matter of claim 1 of the Main Request inventive within the meaning of Article 56 EPC. The reasons and arguments provided above with respect to claim 1 also apply for the system claim 3, because claim 3 includes the same features as claim 1, but formulated as structural features of an apparatus.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the department of first instance with the order to grant a patent in the following version:
Description pages 1-14 as filed with letter dated 28 May 2020;
Claims 1-14 as filed with letter dated 23 June 2020;
Drawings Sheets 1/6-6/6 as published.

The Registrar: The Chairman:

S. Sánchez Chiquero G. Eliasson

Decision electronically authenticated