Title: APPARATUS FOR THE GENERATION OF PARALLEL BEAMLETS

Abstract: The invention relates to an apparatus for the generation of parallel beamlets, comprising a source for particles or radiation, a collimator and, placed between the source and the collimator, a beam splitter for dividing the beam from the source into beamlets, wherein a first macro lens is provided between the source and the beam splitter for forming a substantially parallel beam of rays or beam of particles, and in that between the beam splitter and the collimator, immediately after the beam splitter, a second macro lens is provided.
Apparatus for the generation of parallel beamlets

The invention relates to an apparatus for the generation of parallel beamlets, comprising a source for particles or radiation, a collimator and, placed between the source and the collimator, a beam splitter for dividing the beam from the source into beamlets.

Such an apparatus is known from WO 2004/081910. In a first embodiment of this publication an apparatus is described wherein the beam splitter is formed by a lens array positioned between the source of the principal beam and the collimator. In another embodiment, the lens array is preceded by an aperture array.

The lens array focuses the beamlets in or near the collimator lens, with the intention of avoiding the chromatic aberration of the collimator influencing the position of the source images.

A problem of the known apparatus is that the beamlets do not pass perpendicularly through the lenses of the lens array; especially the outermost beamlets have a considerable angle of incidence in relation to the axis of the lenses, resulting in lens faults such as coma.

The object of the invention is to improve the prior art apparatus so as to prevent the occurrence of the aforementioned lens faults.

To this end the apparatus according to the invention is characterised, in that a first macrolens is provided between the source and the beam splitter for forming a substantially parallel beam of rays or beam of particles, and in that between the beam splitter and the collimator, immediately after the beam splitter, a second macrolens is provided.

The apparatus according to the invention has the advantage that the beam of rays or beam of particles from the source reaches the beam splitter in parallel formation and that the beamlets formed there are formed under the same conditions. Although said first macrolens produces a chromatic effect, this can be compensated by a corresponding opposite
effect of the second macrolens, which causes the beamlets to diverge again.

In this context it is desirable that during operation, the potential of the second macrolens be positive with respect to the beam splitter.

A first suitable embodiment of the apparatus according to the invention is characterised in that the beam splitter is a lens array.

It is, however, equally possible to embody the apparatus according to the invention in a second embodiment such that the beam splitter is an aperture array. Especially this latter embodiment can be realised easily and is nevertheless accurate, since in that case one single plate with openings suffices. The electric field created by the second macrolens on the aperture array forms in each opening a lens for the local beamlet.

In both said embodiments it is advantageous if after the lens array or the aperture array only the second macrolens needs to be provided for the diverging irradiation of the collimator, which second macrolens, owing to its nature, is free from alignment problems.

In a further aspect of the invention, the apparatus is preferably characterised in that directly before the beam splitter, at the side facing the first macrolens, a diaphragm plate is placed. With such a diaphragm plate, which desirably is embodied such that the size of its openings is smaller than that of the beam splitter positioned thereafter, peripheral effects at the beam splitter can be effectively suppressed.

The apparatus according to the invention is very useful in various applications. These include, for example, the application as electron microscope or as high-resolution electron lithographic machine.

Hereinafter the invention will be further elucidated by way of some non-limiting exemplary embodiments and with reference to the drawing.

In the drawing:
- Figure 1 shows an apparatus for the generation of parallel beamlets according to the prior art;
- Figure 2 shows a first embodiment of an apparatus according to the invention, and
- Figure 3 shows a second embodiment of an apparatus according to the invention.

Identical reference numerals used in the figures refer to similar components.

With reference to Figure 1, a short explanation will first be given regarding the apparatus for the generation of parallel beamlets as known from the prior art formed by WO 2004/081910.

Carrying reference numeral 1 in Figure 1 is a source for the generation of a beam, which at a beam splitter 3 is divided into a plurality of beamlets that together pass a collimator 2, whereafter they run parallel to each other.

Figures 2 and 3 show a first and a second embodiment of an apparatus for the generation of parallel beamlets according to the invention.

The beam splitter of the apparatus shown in Figure 2 is a lens array 3. The lens array 3 produces a plurality of source images in the principal plane of the collimator lens 2.

The beam splitter of the apparatus shown in Figure 3 is embodied as aperture array 3'.

Both Figure 2 and Figure 3 show that between the source 1 and the beam splitter 3, 3' a first macrolens 4 is provided for forming a substantially parallel beam of rays or particles, and that between the beam splitter 3, 3' and the collimator 2 a second macrolens 5 is provided directly after the beam splitter 3, 3'.

During operation, the potential of the second macrolens 5 in relation to the beam splitter 3, 3' needs to be positive, which is symbolised by the voltage source 7 creating a potential difference between the beam splitter 3, 3' and the second macrolens 5.

A possible option is to place a diaphragm plate 6 directly before the beam splitter 3, 3' at the side facing
the first macrolens 4. The diameter of the openings of this diaphragm plate 6 is smaller than the effective width of each individual lens of the lens array 3 or of each opening of the aperture array 3', so as to avoid peripheral effects when the beam passes through the lens array 3 or the aperture array 3'. The manner in which this is to be realised is fully known to those skilled in the art so that a further explanatory description of the figures is unnecessary.

Still other variations on the theme of the invention are also possible, without departing from the spirit of the invention and thus also without departing from the protective scope due the invention and embodied in the appended claims.

For example, it is possible to combine the beam splitter 3, 3' described above with deflectors. It is also possible to embody the apparatus with more than one source for particles or radiation so that the diametrical dimensions of the beam may be increased as desired. Such an apparatus provided with several sources has useful applications both as electron microscope and as electron lithographic machine.
CLAIMS

1. An apparatus for the generation of parallel beamlets, comprising a source (1) for particles or radiation, a collimator (2) and, placed between the source (1) and the collimator (2), a beam splitter (3, 3') for dividing the beam from the source (1) into beamlets, \textit{characterised} in that a first macro lens (4) is provided between the source (1) and the beam splitter (3, 3') for forming a substantially parallel beam of rays or beam of particles, and in that between the beam splitter (3, 3') and the collimator (2), immediately after the beam splitter (3, 3') a second macro lens (5) is provided.

2. An apparatus according to claim 1, \textit{characterised} in that during operation, the potential of the second macro lens (5) is positive with respect to the beam splitter (3, 3').

3. An apparatus according to claim 1 or 2, \textit{characterised} in that the beam splitter (3, 3') is a lens array (3).

4. An apparatus according to claim 1 or 2, \textit{characterised} in that the beam splitter (3, 3') is an aperture array (3').

5. An apparatus according to claim 1-4, \textit{characterised} in that directly before the beam splitter (3, 3'), at the side facing the first macro lens (4), a diaphragm plate (6) is placed.

6. An apparatus according to claim 5, \textit{characterised} in that the size of the diaphragm plate's openings is smaller than that of the beam splitter (3, 3') positioned thereafter.

7. An apparatus according to one of the preceding claims, \textit{characterised} in that the same is embodied as electron lithographic apparatus.

8. An apparatus according to one of the claims 1-6, \textit{characterised} in that the same is embodied as electron microscope.
FIG-1. Prior art

FIG-2

FIG-3
## INTERNATIONAL SEARCH REPORT

**International application No**

PCT/NL2006/000260

### A. CLASSIFICATION OF SUBJECT MATTER

INV. H01J37/04 H01J37/30 H01J37/26

According to International Patent Classification (IPC) or to both national classification and IPC

### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO–Internal, WPI Data, PAJ, INSPEC

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>WO 2004/081910 A (MAPPER LITHOGRAPHY IP B.V.; KRUIT, PIETER) 23 September 2004 (2004-09-23) cited in the application page 12, line 3 – page 15, line 19; figures 4-9</td>
<td>1,3-8</td>
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* Further documents are listed in the continuation of Box C.

** Special categories of cited documents :**

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** Date of the actual completion of the international search ** 31 August 2006

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