Patent Claims

1. A device for obtaining a focused image of a specimen, comprising:

an objective lens disposed for examination of the specimen;

a slow focusing stage coupled to the objective lens, wherein the slow focusing stage controls movement of the objective lens;

a dither focus stage including a dither lens, wherein the dither focus stage moves the dither lens;

a focus sensor that provides focus information in accordance with light transmitted via the dither lens;

at least one electrical component that uses the focus information to determine a metric and a first focus position of the objective lens in accordance with the metric, wherein the at least one electrical component includes an error signal component that processes error signal information generated based on the metric to determine the first focus position, wherein the at least one electrical component sends position information to the slow focusing stage for moving the objective lens into the first focus position; and

an image sensor that captures an image of the specimen after the objective lens is moved into the first focus position.

2. The device according to claim 1, wherein the error signal information is determined according to an error signal function using points of a waveform generated based on the metric according to the motion of the dither lens.

3. The device according to claim 2, wherein the error signal function is a contrast error signal function, and wherein the first focus position is determined where the contrast error signal function is zero.

4. The device according to claim 3, wherein the contrast error signal function is determined based on at least three points of a sharpness waveform computed for each of at least one position on a sharpness response curve where the motion of the dither lens is centered.

5. The device according to claim 4, wherein the contrast error signal (CES) may be represented by an equation:

$$CES = (a-c)/b ,$$

where a is a trough of the sharpness waveform, b is a peak of the sharpness waveform, and c is a subsequent trough of the sharpness waveform.

6. The device according to claim 1, further comprising:

an XY moving stage, wherein the specimen is disposed on the XY moving stage, and wherein at least one of the following is provided: (i) the at least one electrical component controls movement of the XY moving stage, or (ii) the XY moving stage is phase locked with the motion of the dither lens.

7. The device according to claim 1, wherein the dither focus stage includes a voice-coil actuated flexured assembly that moves the dither lens in a translational motion.

8. The device according to claim 1, wherein the dither lens is moved at a resonant frequency that is at least 60 Hz, and wherein the at least one electrical component uses the focus information to perform at least 60 focus calculations per second.

9. The device according to claim 1, wherein the focus sensor and the dither focus stage are set to operate bidirectionally, wherein the focus sensor produces the focus information on both an up and down portion of a sinusoid waveform of the motion of the dither lens at the resonant frequency.

10. The device according to claim 1, wherein the metric includes at least one of: contrast information, sharpness information, and chroma information.

11. A method for obtaining a focused image of a specimen, comprising:

controlling movement of an objective lens disposed for examination of the specimen;

controlling motion of a dither lens;

providing focus information in accordance with light transmitted via the dither lens;

using the focus information to determine a metric and determine a first focus position of the objective lens in accordance with the metric, wherein determining the first focus position includes processing error signal information generated based on the metric;

sending position information that is used to move the objective lens into the first focus position.

12. The method according to claim 11, wherein the error signal information is determined according to an error signal function using points of a waveform generated based on the metric according to the motion of the dither lens.

13. The method according to claim 12, wherein the error signal function is a contrast error signal function, and wherein the first focus position is determined where the contrast error signal function is zero.

14. The method according to claim 13, wherein the contrast error signal function is determined based on at least three points of a sharpness waveform computed for each of at least one position on a sharpness response curve where the motion of the dither lens is centered.

15. The method according to claim 14, wherein the contrast error signal (CES) may be represented by an equation:

$$CES = (a-c)/b ,$$

where a is a trough of the sharpness waveform, b is a peak of the sharpness waveform, and c is a subsequent trough of the sharpness waveform.

16. The method according to claim 11, wherein the first focus position is determined as a best focus position, and the method further comprising:

capturing an image of the specimen after the objective lens is moved into the best focus position.

17. The method according to claim 11, wherein the dither lens is moved at a resonant frequency that is at least 60 Hz, and wherein at least 60 focus calculations are performed per second.

18. The method according to claim 11, wherein the metric includes at least one of: sharpness information, contrast information and chroma information.

19. A non-transitory computer readable medium storing software for obtaining a focused image of a specimen, the software comprising:

executable code that controls movement of an objective lens disposed for examination of the specimen;

executable code that controls motion of a dither lens;

executable code that provides focus information in accordance with light transmitted via the dither lens;

executable code that uses the focus information to determine a metric and determine a first focus position of the objective lens in accordance with the metric, wherein determining the first focus position includes processing error signal information generated based on the metric; and

executable code that sends position information that is used to move the objective lens into the first focus position.

20. The non-transitory computer readable medium according to claim 19, wherein the error signal information is determined according to an error signal function using points of a waveform generated based on the metric according to the movement of the dither lens, wherein the error signal information is determined according to an error signal function using points of a waveform generated based on the metric according to the movement of the dither lens, wherein the error signal function is a contrast error signal function, and wherein the first focus position is determined where the contrast error signal function is zero, wherein the contrast error signal function is determined based on at least three points of a sharpness waveform computed for each of at least one position on a sharpness response curve where the movement of the dither lens is centered.

21. A device for obtaining a focused image of a specimen, comprising:

an objective lens disposed for examination of the specimen;

a slow focusing stage coupled to the objective lens, wherein the slow focusing stage controls movement of the objective lens;

a dither focus stage including a dither lens, wherein the dither focus stage moves the dither lens;

a focus sensor that provides focus information in accordance with light transmitted via the dither lens;

at least one electrical component that uses the focus information to determine a metric and a first focus position of the objective lens in accordance with the metric, wherein the at least one electrical component includes an error signal component that processes error signal information generated based on the metric to determine the first focus position, wherein the at least one electrical component sends position information to the slow focusing stage for moving the objective lens into the first focus position; and

an image sensor that captures an image of the specimen on a column-by-column basis, during a scanning of the specimen in a serpentine manner, and wherein when a first column of the specimen is scanned in a first direction, a field of view of the focus sensor is aligned with a second column that is adjacent to the first column, such that focus data of the second column is generated.

22. The device of claim 21, further comprising scanning the second column, in a direction that is reverse to the first direction that the first column was scanned, using the focus data of the second column.

23. The device of claim 22, wherein focus data of the first column is predetermined, and wherein the objective lens is moved into a second focus position when the focus data of the first column differs from the focus data of the second column.

CLAIMS:

1. A device for obtaining a focused image of a specimen, comprising:

an objective lens disposed for examination of the specimen;

a slow focusing stage coupled to the objective lens, wherein the slow focusing stage controls movement of the objective lens;

a dither focus stage including a dither lens, wherein the dither focus stage moves the dither lens;

a focus sensor that provides focus information in accordance with light transmitted via the dither lens;

at least one electrical component that uses the focus information to determine a metric and a first focus position of the objective lens in accordance with the metric, wherein the at least one electrical component includes an error signal component that processes error signal information generated based on the metric to determine the first focus position, wherein the at least one electrical component sends position information to the slow focusing stage for moving the objective lens into the first focus position; and

an image sensor that captures an image of the specimen after the objective lens is moved into the first focus position,

wherein the error signal information is determined according to an error signal function using points of a waveform generated based on the metric according to the motion of the dither lens, and wherein the error signal function is a contrast error signal function, and wherein the first focus position is determined where the contrast error signal function is zero.

2. The device according to claim 1, wherein the contrast error signal function is determined based on at least three points of a sharpness waveform computed for each of at least one position on a sharpness response curve where the motion of the dither lens is centered.

3. The device according to claim 2, wherein the contrast error signal (CES) may be represented by an equation:

$$CES=(a-c)/b,$$

where a is a trough of the sharpness waveform, b is a peak of the sharpness waveform, and c is a subsequent trough of the sharpness waveform

4. The device according to claim 1, further comprising: an XY moving stage, wherein the specimen is disposed on the XY moving stage, and wherein at least one of the following is provided: (i) the at least one electrical component controls movement of the XY moving stage, or (ii) the XY moving stage is phase locked with the motion of the dither lens.

5. The device according to claim 1, wherein the dither focus stage includes a voice-coil actuated flexured assembly that moves the dither lens in a translational motion.

6. The device according to claim 1, wherein the dither lens is moved at a resonant frequency that is at least 60 Hz, and wherein the at least one electrical component uses the focus information to perform at least 60 focus calculations per second.

7. The device according to claim 1, wherein the focus sensor and the dither focus stage are set to operate bi-directionally, wherein the focus sensor produces the focus information on both an up and down portion of a sinusoid waveform of the motion of the dither lens at the resonant frequency.

8. The device according to claim 1, wherein the metric includes at least one of: contrast information, sharpness information, and chroma information.

9. The device according to claim 1, wherein the image sensor is configured to capture the image of the specimen on a column-by-column basis, during a scanning of the specimen in a serpentine manner, and wherein when a first column of the specimen is scanned in a first direction, a field of view of the focus sensor is aligned with a second column that is adjacent to the first column, such that focus data of the second column is generated.

10. The device of claim 9, further comprising scanning the second column, in a direction that is reverse to the first direction that the first column was scanned, using the focus data of the second column.

11. The device of claim 10, wherein focus data of the first column is predetermined, and wherein the objective lens is moved into a second focus position when the focus data of the first column differs from the focus data of the second column.

12. A method for obtaining a focused image of a specimen, comprising:

controlling movement of an objective lens disposed for examination of the specimen;

controlling motion of a dither lens;

providing focus information in accordance with light transmitted via the dither lens;

using the focus information to determine a metric and determine a first focus position of the objective lens in accordance with the metric, wherein determining the first focus position includes processing error signal information generated based on the metric;

sending position information that is used ~o move the objective lens into the first focus position,

wherein the error signal information is determined according to an error signal function using points of a waveform generated based on the metric according to the motion of the dither lens, wherein the error signal function is a contrast error signal function, and wherein the first focus position is determined where the contrast error signal function is zero.

13. A non-transitory computer readable medium storing software for obtaining a focused image of a specimen, the software comprising:

executable code that controls movement of an objective lens disposed for examination of the specimen;

executable code that controls motion of a dither lens;

executable code that provides focus information in accordance with light transmitted via the dither lens;

executable code that uses the focus information to determine a metric and determine a first focus position of the objective lens in accordance with the metric, wherein

determining the first focus position includes processing error signal information generated based on the metric; and

executable code that sends position information that is used to move the objective lens into the first focus position,

wherein the error signal information is determined according to an error signal function using points of a waveform generated based on the metric according to the movement of the dither lens, wherein the error signal function is a contrast error signal function, and wherein the first focus position is determined where the contrast error signal function is zero.

14. The non-transitory computer readable medium according to claim 13, wherein the contrast error signal function is determined based on at least three points of a sharpness waveform computed for each of at least one position on a sharpness response curve where the movement of the dither lens is centered.