SUMMARY OF THE DISCLOSED TECHNIQUE

In accordance with one aspect of the disclosed technique, there is thus provided an apparatus for increasing the resolution of a cryogenically cooled and vacuum-sealed infrared imaging detector. The apparatus includes a two-dimensional detector array of photosensitive pixels arranged in a matrix, a masking filter, optics, shifting means, and a processor. The detector array is successively exposed to an image scene, to acquire multiple imaging samples of the scene. The masking filter is disposed between the detector array and the focal plane of the image scene and is maintained at a fixed position with respect to the detector array. The masking filter reduces the region of the pixels collecting incident radiation from the image scene for each of the imaging samples, such that only a portion of each pixel area of the image scene is imaged onto the corresponding pixel of the detector array. The optics are disposed between the masking filter and the focal plane of the image scene, and direct the incident radiation onto the detector array through the masking filter. The shifting means successively shifts the optical path of the image scene relative to the masking filter, by a shifting increment equal to a fraction of the pixel width of the array pixels and corresponding to a fill factor reduction amount, to provide imaging of different sub-pixel regions in each of the imaging samples. The processor reconstructs an

image frame having a resolution greater than the intrinsic resolution of the detector, by a factor defined by the fill factor reduction amount, from the acquired imaging samples. The masking filter may be integrated with the detector array. The masking filter may include configuring the detector array such that the photosensitive region of the pixels of the array is smaller than the potentially maximum photosensitive region of the pixels. The shifting means may shift the optical path of the image scene relative to the masking filter by repositioning the optics with respect to the masking filter and the detector array. The shifting means may alternatively shift the optical path of the image scene relative to the masking filter by repositioning the masking filter and the detector array with respect to the optics. The f-number of the detector optics may be decreased by a factor corresponding to the fill factor reduction amount. The detector may operate within the wavelength range of approximately 1-15 μm. The detector may be a thermal imaging detector.

In accordance with another aspect of the disclosed technique, there is thus provided a method for increasing the resolution of a cryogenically cooled and vacuum-sealed infrared imaging detector that includes a two-dimensional detector array of photosensitive pixels arranged in a matrix. The method includes the procedures of successively exposing the detector array to an image scene to acquire

multiple imaging samples of the scene, and reducing the region of the pixels collecting incident radiation from the image scene for each of the imaging samples, such that only a portion of each pixel area of the image scene is imaged onto the corresponding pixel of the detector array. The method further includes the procedure of successively shifting the optical path of the image scene relative to a masking filter maintained at a fixed position with respect to the detector array, by a shifting increment equal to a fraction of the pixel width of the array pixels and corresponding to a fill factor reduction amount, to provide imaging of different sub-pixel regions in each of the imaging samples. The method further includes the procedure of reconstructing an image frame having a resolution greater than the intrinsic resolution of the detector, by a factor defined by the fill factor reduction amount, from the acquired imaging samples. The method may further include the procedure of decreasing the f-number of the detector optics by a factor corresponding to the fill factor reduction amount.

In one aspect of the invention there is provided an apparatus for increasing the resolution of a cryogenically cooled and vacuum-sealed infrared imaging detector, comprising:

a two-dimensional detector array of photosensitive pixels arranged in a matrix, said detector array having a fill factor value, said detector array successively exposed to an image scene, to acquire multiple infrared imaging samples of said scene;

a masking filter integrated with said detector array and disposed between said detector array and said image scene, said masking filter operative to mask part of an active region of each of said photosensitive pixels thereby reducing said fill factor value of said detector array by a fill

factor reduction amount, such that only a sub-region of a pixel region of said image scene is imaged onto the corresponding masked pixel of said detector array;

optics, disposed between said masking filter and said image scene, said optics operative to direct said image scene onto said detector array through said masking filter;

shifting means, for successively shifting said image scene relative to said detector array between each of said imaging samples, by a shifting increment corresponding to said fill factor reduction amount and smaller than an unmasked active region of a masked photosensitive pixel, wherein each masked photosensitive pixel of said detector receives partially over-lapping sub-regions in said imaging samples; and

a processor, operative for reconstructing an image frame from said acquired imaging samples, the reconstructed image frame having a resolution greater than the intrinsic resolution of said detector by a factor defined by said fill factor reduction amount.

In another aspect of the invention, there is provided a method for increasing the resolution of a cryogenically cooled and vacuum-sealed infrared imaging detector comprising a two-dimensional detector array of photosensitive pixels arranged in a matrix, the detector array having a fill factor value, the method comprising the procedures of:

successively exposing said detector array to an image scene, to acquire multiple infrared imaging samples of said scene;

reducing said fill factor value of said detector array by a fill factor reduction amount by masking part of an active region of each of said photosensitive pixels for each of said imaging samples, via a masking filter integrated with said detector array, such that only a sub-region of a pixel region of said image scene is imaged onto a corresponding masked photosensitive pixel of said detector array;

successively shifting said image scene relative to said detector array between each of said imaging samples, by a shifting increment corresponding to said fill factor reduction amount and smaller than an unmasked active region of a masked photosensitive pixel and, wherein each masked photosensitive pixel of said detector receives partially over-lapping sub-regions in said imaging samples; and

reconstructing an image frame from said acquired imaging samples, the reconstructed image frame having a resolution greater than the intrinsic resolution of said detector by a factor defined by said fill factor reduction amount.

CLAIMS

1. An apparatus for increasing the resolution of a cryogenically cooled and vacuum-sealed infrared imaging detector, comprising:

a two-dimensional detector array of photosensitive pixels arranged in a matrix, said detector array having a fill factor value, said detector array successively exposed to an image scene, to acquire multiple infrared imaging samples of said scene;

a masking filter integrated with said detector array and disposed between said detector array and said image scene, said masking filter operative to mask part of an active region of each of said photosensitive pixels thereby reducing said fill factor value of said detector array by a fill factor reduction amount, such that only a sub-region of a pixel region of said image scene is imaged onto the corresponding masked pixel of said detector array;

optics, disposed between said masking filter and said image scene, said optics operative to direct said image scene onto said detector array through said masking filter;

shifting means, for successively shifting said image scene relative to said detector array between each of said imaging samples, by a shifting increment corresponding to said fill factor reduction amount and smaller than an unmasked active region of a masked photosensitive pixel, wherein each masked photosensitive pixel of said detector receives partially over-lapping sub-regions in said imaging samples; and

a processor, operative for reconstructing an image frame from said acquired imaging samples, the reconstructed image frame having a resolution greater than

the intrinsic resolution of said detector by a factor defined by said fill factor reduction amount.

2. The apparatus of claim 1, wherein a number of said multiple imaging samples of said scene corresponds to said fill factor reduction amount.

3. The apparatus of claim 1, wherein said shifting means shifts the optical path of said image scene relative to said masking filter by repositioning said optics with respect to said masking filter and said detector array.

4. The apparatus of claim 1, wherein said shifting means shifts the optical path of said image scene relative to said masking filter by repositioning said masking filter and said detector array with respect to said optics.

5. The apparatus of claim 1, wherein the f-number of the detector optics is decreased by a factor corresponding to said fill factor reduction amount.

6. The apparatus of claim 1, wherein said detector is operative within the wavelength range of 1–15 μm.

7. The apparatus of claim 1, wherein said detector is a thermal imaging detector.

8. A method for increasing the resolution of a cryogenically cooled and vacuum-sealed infrared imaging detector comprising a two-dimensional detector array of

photosensitive pixels arranged in a matrix, the detector array having a fill factor value, the method comprising the procedures of:

successively exposing said detector array to an image scene, to acquire multiple infrared imaging samples of said scene;

reducing said fill factor value of said detector array by a fill factor reduction amount by masking part of an active region of each of said photosensitive pixels for each of said imaging samples, via a masking filter integrated with said detector array, such that only a sub-region of a pixel region of said image scene is imaged onto a corresponding masked photosensitive pixel of said detector array;

successively shifting said image scene relative to said detector array between each of said imaging samples, by a shifting increment corresponding to said fill factor reduction amount and smaller than an unmasked active region of a masked photosensitive pixel and, wherein each masked photosensitive pixel of said detector receives partially over-lapping sub-regions in said imaging samples; and

reconstructing an image frame from said acquired imaging samples, the reconstructed image frame having a resolution greater than the intrinsic resolution of said detector by a factor defined by said fill factor reduction amount.

9. The method of claim 8, further comprising decreasing the f-number of the detector optics by a factor corresponding to said fill factor reduction amount.

SUMMARY OF THE DISCLOSED TECHNIQUE

In accordance with one aspect of the disclosed technique, there is thus provided an apparatus for increasing the resolution of a cryogenically cooled and vacuum-sealed infrared imaging detector. The apparatus includes a two-dimensional detector array of photosensitive pixels arranged in a matrix, a masking filter, an optical element, shifting means, and a processor. The detector array is operative within the wavelength range of 1–15 μm and is successively exposed to an image scene, to acquire multiple imaging samples of the scene. The masking filter is disposed between the detector array and the image scene and is maintained at a fixed position with respect to the detector array. The masking filter masks part of the active region of the pixels within the wavelength range of 1–15 μm by a fill factor reduction amount, for each of the imaging samples, such that only a portion of each pixel area of the image scene is imaged onto the corresponding masked pixel of the detector array. The optics are disposed between the masking filter and the image scene, and direct the incident radiation onto the detector array through the masking filter. The shifting means successively shifts the optical path of the image scene relative to the masking filter and the detector array between each of the imaging samples, by a shifting increment corresponding to the fill factor reduction amount, to provide imaging of different sub-pixel regions in each of the imaging samples. The processor reconstructs an image frame from the acquired imaging samples, the reconstructed image frame having a resolution greater than the intrinsic resolution of the detector, by a factor defined by the

fill factor reduction amount. The masking filter may be a coating disposed on the detector array. The masking filter may include configuring the detector array such that the photosensitive region of the pixels of the array is smaller than the potentially maximum photosensitive region of the pixels. The shifting means may shift the optical path of the image scene relative to the masking filter by repositioning the optics with respect to the masking filter and the detector array. The shifting means may alternatively shift the optical path of the image scene relative to the masking filter and the detector array by jointly repositioning the masking filter and the detector array with respect to the optics. The f-number of the detector optics may be selected in accordance with to the fill factor reduction amount to provide a selected sensitivity of the detector. The selected sensitivity of the detector may correspond to the sensitivity of a non-fill factor reduced detector. The detector may be a thermal imaging detector.

In accordance with another aspect of the disclosed technique, there is thus provided a method for increasing the resolution of a cryogenically cooled and vacuum-sealed infrared imaging detector that includes a two-dimensional detector array of photosensitive pixels arranged in a matrix, the detector array operative within the wavelength range of 1–15 μm. The method includes the procedures of successively exposing the detector array to an image scene to acquire multiple imaging samples of the scene, and masking part of the active region of the pixels within the wavelength range of 1–15 μm by a fill factor reduction amount, for each of the imaging samples, via

a masking filter disposed within the cryogenic storage dewar and maintained at a fixed position with respect to the detector array, such that only a portion of each pixel area of the image scene is imaged onto the corresponding masked pixel of the detector array. The method further includes the procedure of successively shifting the optical path of the image scene relative to the masking filter and the detector array between each of the imaging samples, , by a shifting increment corresponding to the fill factor reduction amount, to provide imaging of different sub-pixel regions in each of the imaging samples. The method further includes the procedure of reconstructing an image frame from the acquired imaging samples, the reconstructed image frame having a resolution greater than the intrinsic resolution of the detector, by a factor defined by the fill factor reduction amount. The method may further include the procedure of selecting the f-number of the detector optics in accordance with the fill factor reduction amount to provide a selected sensitivity of the detector. The selected sensitivity of the detector may correspond to the sensitivity of a non-fill factor reduced detector.

CLAIMS

1. An apparatus for increasing the resolution of a cryogenically cooled and vacuum-sealed infrared imaging detector, comprising:

a two-dimensional infrared detector array of photosensitive pixels arranged in a matrix, the detector array operative within the wavelength range of 1–15 μm, the detector array configured to be successively exposed to an image scene, to acquire multiple imaging samples of the scene;

a masking filter, disposed between the detector array and the image scene and maintained at a fixed position with respect to the detector array, the masking filter configured to mask part of the active region of the pixels within the wavelength range of 1-15 μm by a fill factor reduction amount, for each of the imaging samples, such that only a portion of each pixel area of the image scene is imaged onto the corresponding masked pixel of the detector array;

optics, disposed between the masking filter and the image scene, the optics configured to direct the incident radiation onto the detector array through the masking filter;

shifting means, for successively shifting the optical path of the image scene relative to the masking filter and the detector array between each of the imaging samples, by a shifting increment corresponding to the fill factor reduction amount, to provide imaging of different sub-pixel regions in each of the imaging samples; and

a processor, configured to reconstruct an image frame from the acquired imaging samples, the reconstructed image frame having a resolution greater than the intrinsic resolution of the detector by a factor defined by the fill factor reduction amount.

2. An apparatus according to Claim 1, in which the masking filter comprises a coating disposed on the detector array.

3. An apparatus according to Claim 1, in which the masking filter comprises configuring the detector array such that the photosensitive region of the pixels of the array is smaller than the potentially maximum photosensitive region of the pixels.

4. An apparatus according to Claim 1, in which the shifting means is configured to shift the optical path of the image scene relative to the masking filter and the detector array by repositioning the optics with respect to the masking filter and the detector array.

5. An apparatus according to Claim 1, in which the shifting means is configured to shift the optical path of the image scene relative to the masking filter and the detector array by jointly repositioning the masking filter and the detector array with respect to the optics.

6. An apparatus according to Claim 1, in which the f-number of the detector optics is selected in accordance with the fill factor reduction amount to provide a selected sensitivity of the detector.

7. An apparatus according to Claim 6, in which the selected sensitivity of the detector corresponds to the sensitivity of a non-fill factor reduced detector.

8. An apparatus according to Claim 1, in which the detector is a thermal imaging detector.

9. A method for increasing the resolution of a cryogenically cooled and vacuum-sealed infrared imaging detector comprising a two-dimensional infrared detector array of photosensitive pixels arranged in a matrix, the detector array operative within the wavelength range of 1–15 μm, the method comprising the procedures of:

successively exposing the detector array to an image scene, to acquire multiple imaging samples of the scene;

masking part of the active region of the pixels within the wavelength range of 1-15 μm by a fill factor reduction amount for each of the imaging samples, via a masking filter maintained at a fixed position with respect to the detector array, such that only a portion of each pixel area of the image scene is imaged onto the corresponding masked pixel of the detector array;

successively shifting the optical path of the image scene relative to the masking filter and the detector array between each of the imaging samples, , by a shifting increment corresponding to the fill factor reduction amount, to provide imaging of different sub-pixel regions in each of the imaging samples; and

reconstructing an image frame from the acquired imaging samples, the reconstructed image frame having a resolution greater than the intrinsic resolution of the detector by a factor defined by the fill factor reduction amount.

10. A method according to Claim 9, further comprising the procedure of selecting the f-number of the detector optics in accordance with the fill factor reduction amount to provide a selected sensitivity of the detector.

11. A method according to Claim 10, in which the selected sensitivity of the detector corresponds to the sensitivity of a non-fill factor reduced detector.