SCIENTIFIC SUPERRESOLUTION CAMERAS

PRELIMINARY DATA SHEET

GE-S 2048 2048 BI

FIRST OF ITS KIND WORLDWIDE

GE-S 1024 1024 series **GE-S 1024 256 series** **GE-S 2048 512 series**
GE-S 2048 2048 series **GE-S 4096 4096 series** **In-Vacuum series**

The scientific superresolution cameras from greateyes form a completely new class of scientifc cameras for high performance spectroscopy and imaging from the near-infrared to X-ray region. At its heart, the latest technology advancement provides true subpixel resolution of the detector, and thus offering increased spatial or spectral resolution in comparison to the standard scientific cameras.

Greateyes scientific cameras are known for their ultra low readout noise, exceptional high quantum efficiencies, low dark currents by deep sensor cooling and highest dynamic range. The latter requires a large pixel size with an associated high full well capacity. As a consequence, the spatial resolution of the standard scientific cameras is limited. The novel greateyes camera class integrates the superresolution technique to achieve effective subpixel resolution. For this purpose, several images are aquired, each with the detector shifted stepwise in the subpixel micrometer range. From the set of individual frames an image with higher resolution is generated. The entire measurement sequence is fully automated.

The innovative technology is available for all greateyes camera series. This paper provides insight in the technology, its capabilities and applications. Please see individual data sheets for each camera series for ordering details.

Features

Scientific low noise CCD sensors	Subpixel resolution	Quantum efficiency of up to 98%
Full well capacity up to 700,000 e^-	Variety of different CCD formats	Deep cooling to max. -100°·C
Read noise: min. 2.4 e^-	Display of sensor and camera temp.	max. 18 bit dynamic range
Wide spectral sensitivity	Flexible binning modes	greateyes Vision software included
SDK & Labview and EPICS drivers	Ext. trigger, shutter, sync signals	Water and forced air cooling

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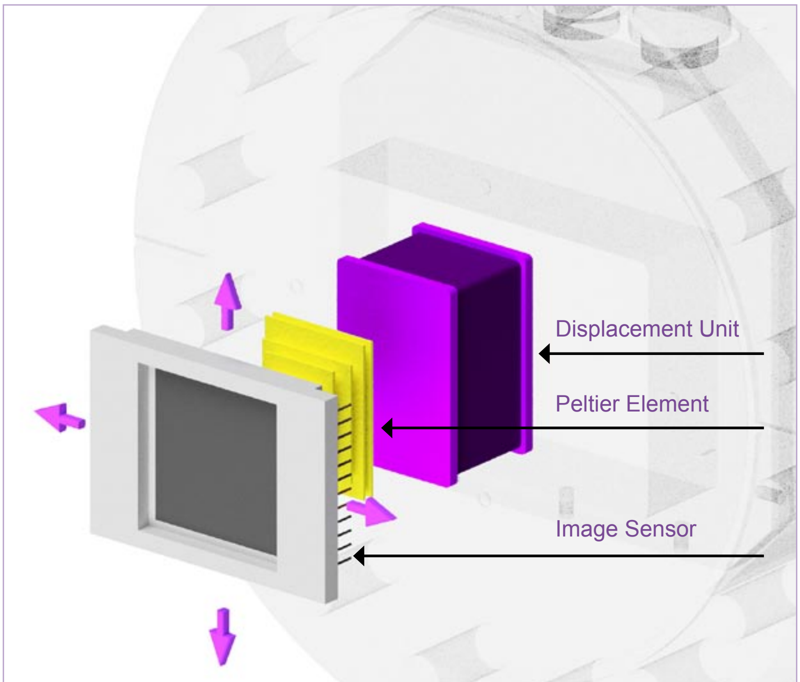
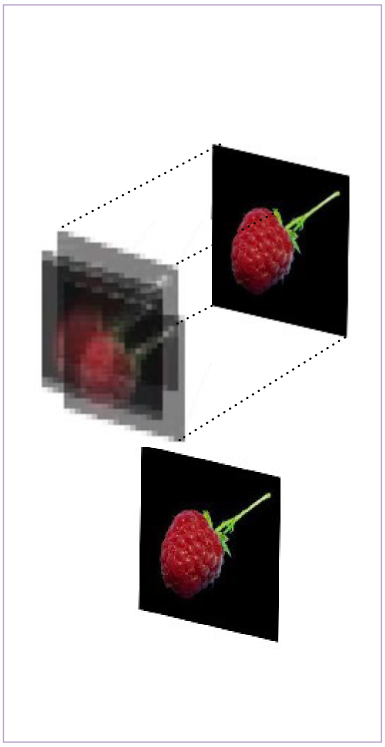


Exploded Assembly Drawing / Patents pending.



TECHNICAL APPROACH

The scientific superresolution cameras integrate a very compact x-y displacement unit beneath the image sensor and thermoelectric cooling device. The software enables the user to choose a predefined measurement sequence depending on the desired resolution. For example a 2 x 2 image subset results in a four fold larger final image size with respect to the image sensor of the cameras. The software aquires 2 x 2 = 4 sequential frames, each with the sensor displaced in x and y direction within the subpixel micrometer range. An algorithm eventually generates the final superresolution image from the individual frames.

Acquisition of a superresolution image is as simple as taking a single image. All other performance parameters are the same as for standard scientific greateyes cameras.

greateyes standard camera series	Available scientific superresolution camera series
GE 1024 1024 xxx Sensor: 1024 x 1024 pixel (1 Mpx), 13µm pixel size	GE-S 1024 1024 xxx **typ. image: 2048 x 2048 (4.2 Mpx), eff. pixel size: ≤ 8.2 µm**
GE 2048 2048 xxx Sensor: 2048 x 2048 pixel (4.2 Mpx), 13.5 pixel size	GE-S 2048 2048 xxx **typ. image: 4096 x 4096 (16.7 Mpx), eff. pixel size: ≤ 8.4 µm**
GE 4096 4096 xxx Sensor: 4096 x 4096 Pixel (16 Mpx), 15 µm pixel size	GE-S 4096 4096 xxx **typ. image: 8192 x 8192 (67.1 Mpx), eff. pixel size: ≤ 9.4 µm**
GE 1024 256 xxx Sensor: 1024 x 256 Pixel (0.25Mpx), 26 µm pixel size	GE-S 1024 256 xxx **typ. image: 2048 x 512 (1 Mpx), eff. pixel size: ≤ 16.3 µm**
GE 2048 512 xxx Sensor: 2048 x 512 Pixel (1 Mpx), 13.5 µm pixel size	GE-S 2048 512 xxx **typ. image: 4096 x 1024 (4.2 Mpx), eff. pixel size: ≤ 8.4 µm**

For further technical informations please have a look also on the respective camera data sheets.

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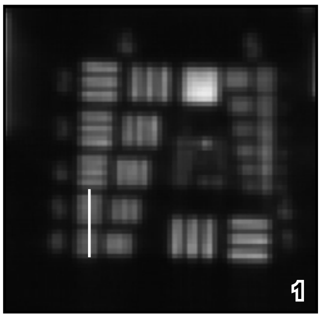
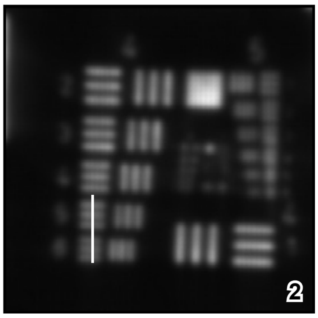
CHARACTERISATION

1951 USAF resolution test chart, 4 x 4 image frames → Superresolution image

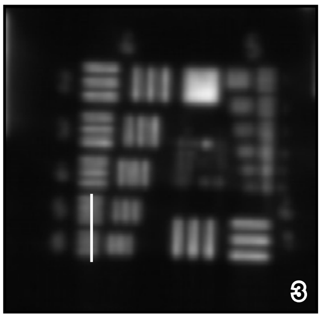
Reference pattern



Single camera image

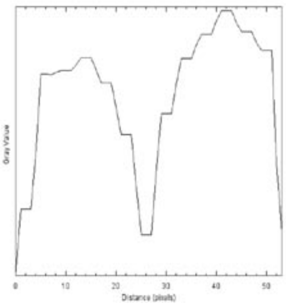


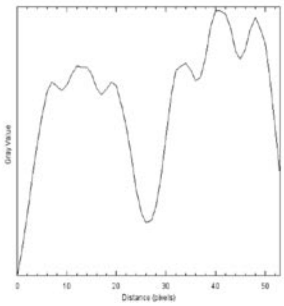
Superresolution image

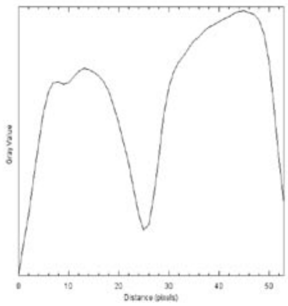


Interpolation image

Intensity line profiles







RESULTS

For performance evaluation, the superresolution camera (Model: GE-S 1024 1024 BI UV1 based on a scientific, back-illuminated CCD sensor with 1024×1024 pixels, 13.5µm x 13.5µm pixel size) is mounted to an optical microscope. The point spread function (PSF) of the microscope has to be significantly smaller than the pixel size of the detector in order to observe true subpixel resolution.

The upper left image shows the principal structure of the imaged reference pattern (1951 USAF resolution test chart) consisting of groups of three bars. Images 1-3 compare the standard single image aquired by the camera and the superresolution image obtained from a set of 4×4 individual frames with the sensor being automatically shifted to defined subpixel positions. For reference, an interpolated image is shown as well. The superresolution image has a significantly higher information content compared to both the original image and the interpolated image. The true subpixel resolution performance is also clearly seen in the intensity line profiles. The white line in the images 1-3 indicates the intersection selected for the intensity profiles.

The achievable subpixel detector resolution has been determined to be a factor of 1.6 better than the sensor pixel size for each direction (x,y) but optimal experimental layout may yield even better results. The table on the left page lists the available standard scientific cameras and the typical gain in image size and effective subpixel resolution for the superresolution camera variants.

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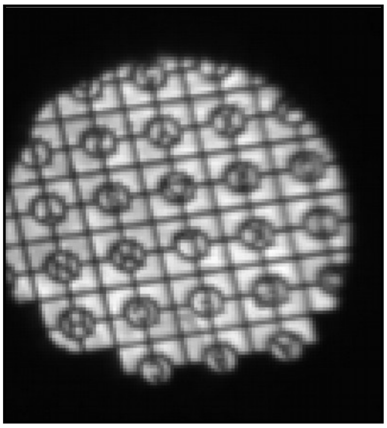
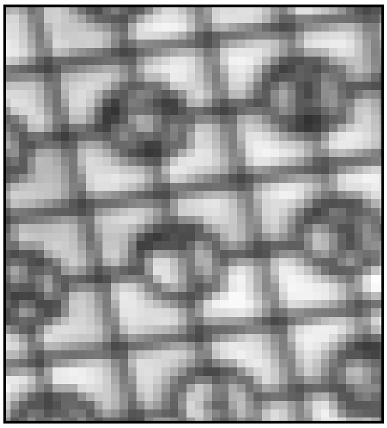
IMAGING RESULTS

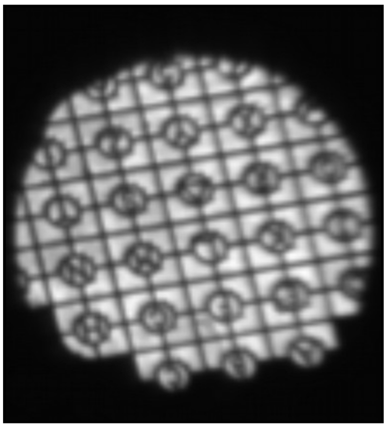
Pattern HF15 Mesh 135



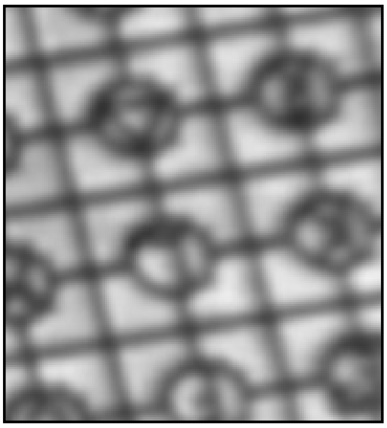
Original Image



Original Image



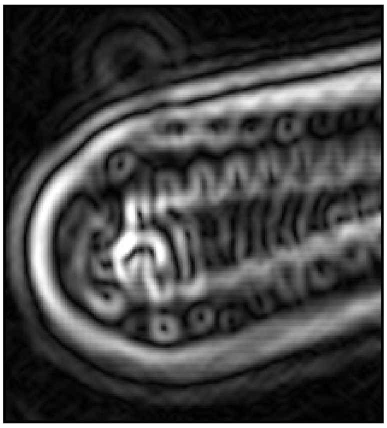
Superresolution Image



Superresolution Image

Diatom, edge filter applied

Original Image



Superresolution Image

APPLICATIONS

Low light imaging with improved, subpixel resolution in the range from NIR to X-ray

Various types of spectroscopy with increased spectral resolution from NIR to X-Ray

Emerging applications like EUV and soft X-Ray microscopy, EUV mask inspection

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