



InfraScope Thermal Mapper (XP)

User's Manual

September 12, 2006

The logo consists of the letters "QFI" in a bold, white, sans-serif font. The letter "Q" is stylized with a small circle at the top left. The letters are set against a solid blue rectangular background.	1 of 70	www.quantumfocus.com Quantum Focus Instruments Corp, Vista, CA USA
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([Table of Contents](#) Follows Quick Start Guide)

0 InfraScope Quick Start

0.1 InfraScope Quick Start Guide

What you will be doing:

1. Prep: Cool the camera; mount and secure the sample, heat the stage.
2. Power the system & launch the software.
3. Acquire an unpowered Reference Image.
4. Acquire a powered Temperature Image.
5. Save the job.

How quickly to do it:

- Pour fill the LN2 into the InfraScope camera. Fill it about half full or until you see volumes of mist streaming out. Stop. Wait for a few minutes for the boiling to subside, then completely fill the dewar. It is full when a small amount of LN2 dribbles gently out under the funnel. Wait a few minutes for equilibration before taking data.
- Power up the InfraScope with the green button on the face of the rack and launch the InfraScope application.
- If you don't have a joystick and you do have an automated X,Y,Z stage, launch the QFI Motion Applet for focusing and navigating.
- Mount the device on the thermal stage. Very important: secure the device against motion or the data will be spoiled. Attach the power wires and verify electrical function.
- Manual system: Rotate the turret to the low magnification infrared lens.
- Automated system: Choose the Lens Turret tab, choose the low mag IR lens.
- Using the mouse, press the "Thermal Stage" tab and set the stage temperature to 70°C.
- Choose the Acquire Tab and press the " R_{ref} " button with the mouse to get a live image.
- Use the appropriate control for your system to center and focus the part to be tested.
- When satisfied with focus and placement, stop the R_{ref} Acquisition. This is the beginning of the measurement sequence. Pressing 'Stop' acquires the R_{ref} image in the frame buffers and automatically calculates the emissivity map.
- Using the mouse, choose the "map 1" radio button and press the " T_{1-4} " button, and". This will start the temperature image acquisition of the still unpowered device.
- The image should be largely uniform, at pretty nearly one temperature, without dramatic edges or with severe color shifts. The goal is a uniform image with random noise. The max and min temperatures on the color bar should not be excessively far apart. If they are, microscope or sample movement compromised the emissivity calculation. Do not proceed. Recheck the sample for secure mounting. Ask your colleagues to step away from the InfraScope. Retake the Reference Radiance image (R_{ref} button) and repeat through taking "T1" again.
- When satisfied with the unpowered temperature image, power up your device and acquire the desired temperature image.
- Save the "job" with the menu "File" command.

		2 of 70	www.quantumfocus.com Quantum Focus Instruments Corp, Vista, CA USA
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1 Table of Contents

0	InfraScope Quick Start.....	2
0.1	InfraScope Quick Start Guide	2
1	Table of Contents	3
2	Physics of Infrared Thermal Mapping	6
2.1	Overview	6
2.2	Blackbody Radiation.....	6
2.3	Blackbody Sources.....	7
2.4	Kirchoff's Law & Emissivity.....	8
2.5	Silicon Transmission – Backside Inspection	9
2.6	Useful Take-Away Points	9
3	InfraScope Models	10
3.1	InfraScope 3	10
3.2	InfraScope II	10
3.3	InfraScope I	10
4	Normal Operation	11
4.1	Basic Setup.....	11
4.1.1	Vibration Isolation	11
4.1.2	Air Currents – Air Conditioning	11
4.2	Liquid Nitrogen (LN2).....	11
4.3	Sample Preparation	12
4.3.1	Decapsulation.....	12
4.3.2	Sample Mounting.....	12
4.3.3	Sample Heating for True Temperature Measurements	12
4.3.4	Sample Heating for Failure Analysis detection of Short Circuits.....	12
4.3.5	Sample Heating for Improved Sensitivity.....	12
4.4	Sample Placement.....	13
4.5	Initial Focusing and Sample Centering.....	13
4.6	Changing Lenses	13
4.7	True Temperature Thermal Mapping.....	13
4.7.1	R_{ref} - Radiance Reference	13
4.7.2	T_{1-4} Unpowered Temperature image.....	14
4.7.3	Powered Temperature Image T_{1-4}	14
4.7.4	Adjusting the Range.....	14
4.8	Delta Radiance Fault Isolation Method	15
4.9	Image Overlay.....	15
4.9.1	Overlay by Thresholding and Scaling.....	15
4.9.2	Enhanced Reference Image.....	17
4.9.3	Manual Scale Assistant	18
4.10	Movies.....	19
4.11	Saving the job	19

		3 of 70	www.quantumfocus.com Quantum Focus Instruments Corp, Vista, CA USA
---	--	---------	--

4.12	Exporting the Data	20
4.12.1	Exporting with Paint Shop Pro	20
4.12.2	Exporting directly from InfraScope	20
4.13	Manual Temperature Control.....	20
4.14	Using the anti-convection Fan	20
4.14.1	Maintains Thermal Accuracy.....	20
4.14.2	Anti-Convection.....	21
5	InfraScope Software Description.....	21
5.1	Software Introduction	21
5.2	Launch & Initialization.....	21
5.2.1	Headmaster.....	21
5.2.2	Stagemaster.....	22
5.3	Main Screen Menu.....	22
5.4	Tabbed Commands	22
5.4.1	Typical Sequence of Use	23
5.4.2	Acquire Tab.....	24
5.4.3	View Tab.....	27
5.4.4	Analyze Tab	30
5.4.5	Calibration Tab	31
5.4.6	Movie Tab.....	32
5.4.7	Temp Range Tab	34
5.4.8	Camera Tab	35
5.4.9	Lens Turret Tab	36
5.4.10	Thermal Stage Tab	37
5.4.11	Power Tab	37
5.4.12	Light Tab.....	38
5.4.13	ROI Tab	39
5.4.14	Stack Tab.....	41
5.5	Pull Down Menus	41
5.5.1	Overview	41
5.5.2	File Menu	41
5.5.3	Edit Menu.....	42
5.5.4	Config Menu.....	42
5.5.5	Acquire Menu	43
5.5.6	View Menu.....	43
5.5.7	Analyze Menu	43
5.5.8	Minimize InfraScope!	43
5.6	Image Information & Adjustment Regions.....	44
5.6.1	Image Scaling	44
5.6.2	Zoom & Scroll	45
5.6.3	Image Information	45
5.7	Image Acquisition Messages and Dialogs	45
5.7.1	Background Out of Bounds	45
5.7.2	Pre-Acquire	46
5.7.3	Acquire.....	46

		4 of 70	www.quantumfocus.com Quantum Focus Instruments Corp, Vista, CA USA
---	--	---------	--

5.7.4	Image Display	48
6	Maintenance & Calibration.....	49
6.1	Recommended Service Intervals.....	49
6.2	Periodic Calibration	49
6.2.1	Lens to Lens Calibration	49
6.2.2	Radiance Calibration.....	51
6.2.3	Uniformity Calibration.....	54
6.2.4	Bad Pixel Mapping	56
6.2.5	Emissivity Calibration	59
6.3	Periodic Maintenance.....	59
6.3.1	Cleaning Objective Lenses	59
6.3.2	Cleaning the Optical Head	60
6.3.3	Poor Dewar Hold Time / Pumping the Dewar	60
6.4	Packing the InfraScope for Moving or Service.....	62
6.4.1	Removing and Packing the Optical Head	62
6.4.2	Preparing the stages for shipment	63
6.4.3	Preparing the Rack and Electronics for Shipment	63
7	Advanced Techniques	64
7.1	Thermal Transient.....	64
7.1.1	Description.....	64
7.2	RADIANCE COMPARISON TEMPERATURE METHOD	65
7.2.1	RCT Procedure.....	66
7.3	2 TEMPERATURE EMISSIVITY METHOD.....	66
7.4	OTHER EMISSIVITY METHODS	66
7.5	AVI capture.....	66
7.6	Sample Painting	66
8	Trouble Shooting	67
8.1	No Image.....	67
8.2	Poor Hold Time for Camera LN2	67
8.3	Flashing Screen / Bad Pixels.....	67
8.4	Pale Images, Color Bar Temperature Range Exceeds expected range.	67
8.5	Message “Unexpected Counts / Background Counts out of range”	67
8.6	X,Y, or Z stage doesn’t move	68
8.7	Removing persistent drawn boxes and drawn lines from image	68
8.8	Green On / Off button doesn’t work, or Emergency Off button doesn’t work.....	68
8.9	Columns in Image / Non-uniformity.....	68
8.10	Lots of red and blue edges in the unpowered or powered temperature image.	68
8.11	Wrong Temperature Measurements.....	68
8.12	Cutting and Pasting a Screen Image:	69
8.13	What is the logon password?	70

2 Physics of Infrared Thermal Mapping

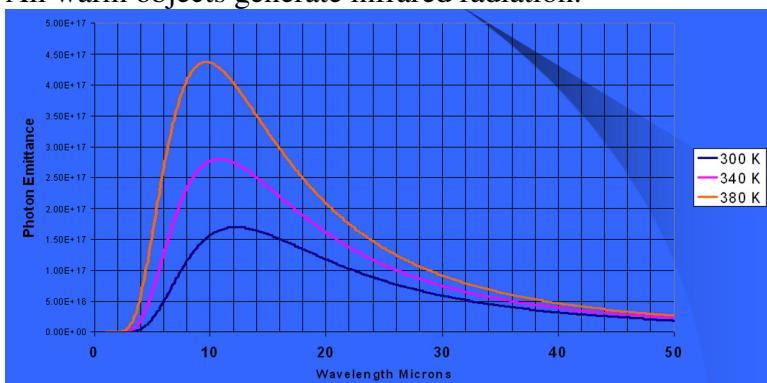
2.1 Overview

The InfraScope detects and measures infrared light emanating directly from the sample. The accuracy of the measurement is influenced by the base temperature of the sample, by the material properties of the sample (emissivity), by the I^2R power consumed in the sample, and to a small but sometimes important extent by the room ambient temperature. The InfraScope Thermal Mapper algorithms when used carefully will compensate for these variables and will return accurate circuit temperatures.

Planck's Radiation Law

2.2 Blackbody Radiation

All warm objects generate infrared radiation.



These curves show the infrared radiation from black objects that are at room ambient or some tens of degrees above ambient. Virtually every natural object in the world is at 300 Kelvin, plus or minus say 50 or 60 Kelvin degrees. So there is useful infrared radiation everywhere for example, for military thermal night vision.

The equations that describe this radiation are:

$$W_\lambda = \frac{2\pi hc^2}{\lambda^5} \frac{1}{e^{c_2/\lambda T} - 1}$$

Planck's Blackbody Law

This equation generated the plot seen above.

		6 of 70	www.quantumfocus.com Quantum Focus Instruments Corp, Vista, CA USA
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$$Q = \epsilon \sigma' T^3$$

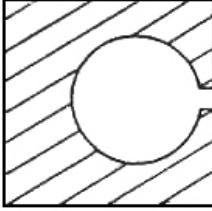
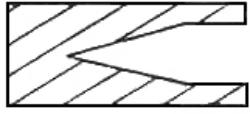
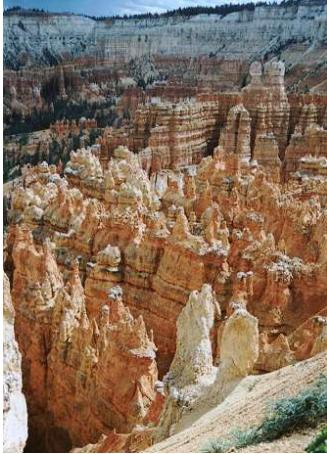
Stefan Boltzman Law (for photons)

The Stefan Boltzman Law is the Planck Equation integrated over all wavelengths and reformulated here for photon generation rather than power (watts). The important thing to note about the Stefan Boltzman Law is that the photons emitted from a source increase as the cube of absolute temperature. This means that a given thermal source will generate more photons if the sample ambient is higher.

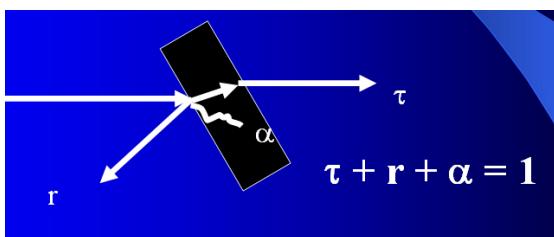
In the realm of visible light if we want to make a dark space, we can switch off the lights and perhaps enclose the space in a light tight box. In the infrared this isn't possible, since even the walls of the light-tight box are emitting infrared light. The only way to turn off the lights in the infrared is to cool the source.

2.3 Blackbody Sources

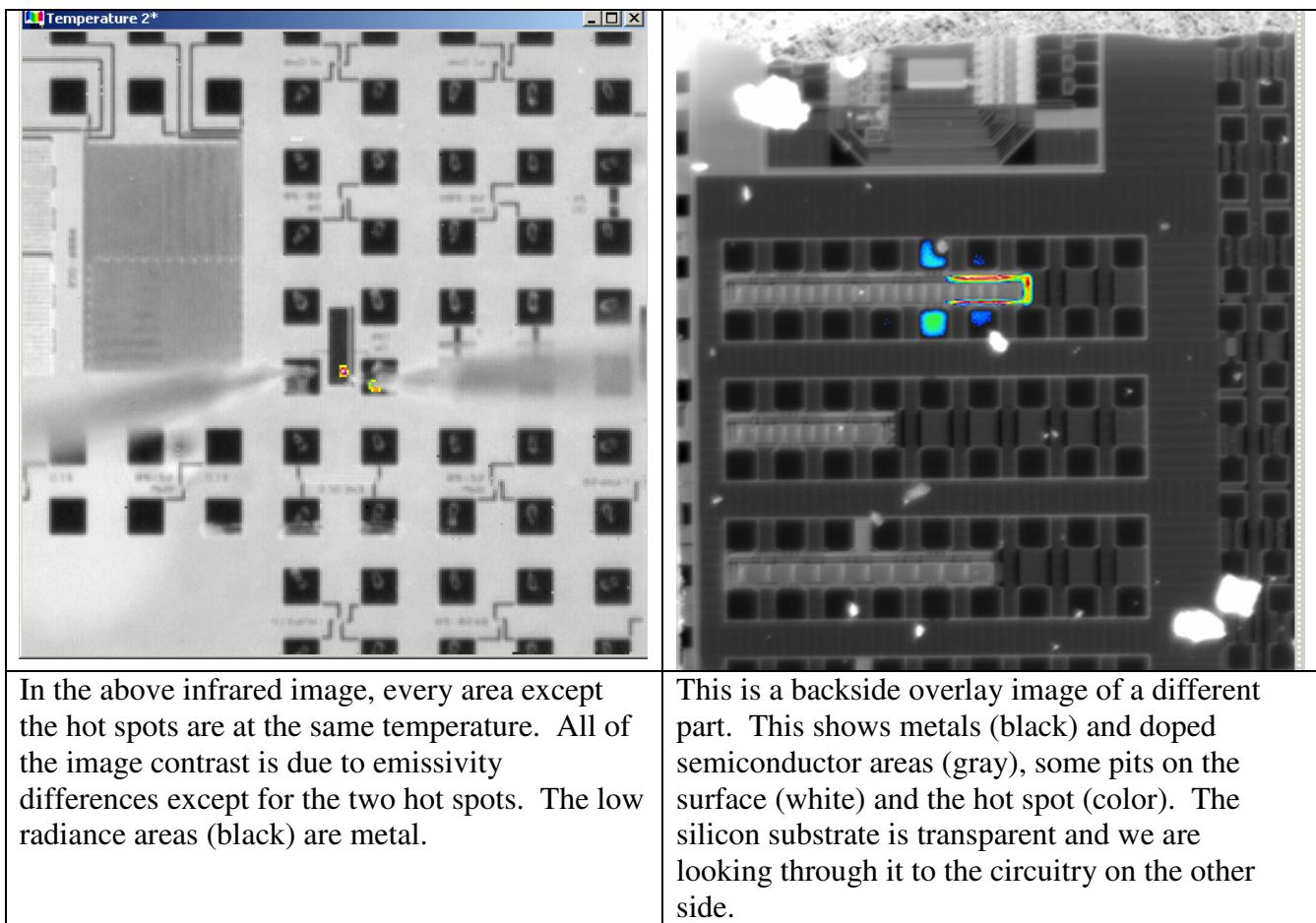
Not all objects emit infrared with equal efficiency. A perfect emitter is known as a blackbody. All the radiation from a blackbody source is characteristic of its temperature.

 <p>Blackbody Shapes</p>  <p>(A) SPHERICAL (B) CONICAL</p>		
<p>These Blackbody cavity shapes absorb light so efficiently that they appear black. Light coming out of these sources is characteristic of the cavity surface temperature, and not the temperature of the area outside the source.</p>		<p>If a surface is rough compared to the wavelength it will approximate a blackbody source. If the features of Bryce Canyon shown above appeared on the scale of microns this surface would appear black to the InfraScope.</p>

2.4 Kirchoff's Law & Emissivity

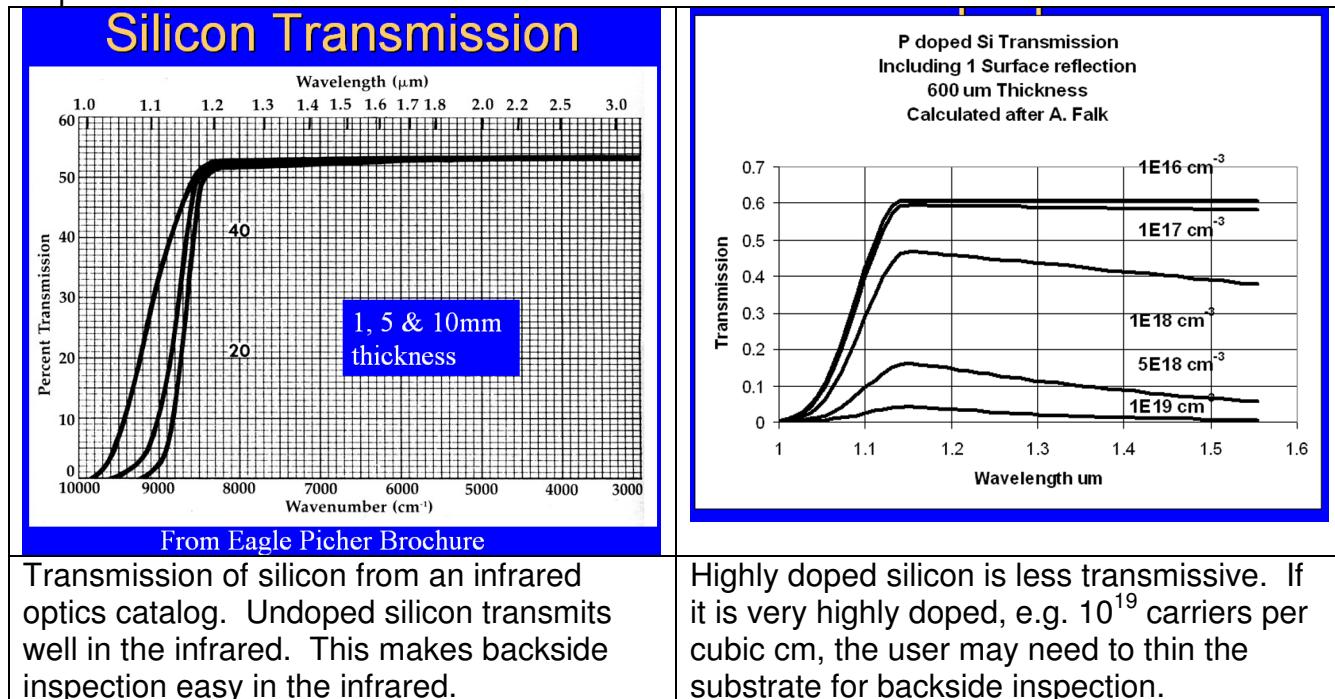


Energy conservation requires that energy impinging on a material must either pass through, be absorbed or be reflected. These properties are called transmissivity, absorbtivity and reflectivity. The sum of these 3 properties for any material must add to unity. Good absorbers are equally good emitters. So emissivity can be substituted for absorbtivity. Metals tend to be very reflective. Undoped silicon is transmissive in the infrared. Doped silicon is absorptive and therefore emissive. Plastics, ceramics, glue and many organics are very absorptive (and therefore very emissive).



2.5 Silicon Transmission – Backside Inspection

The curves below show that silicon wafers begin transmitting light when the wavelength approaches and exceeds 1.1 um. There is a considerable difference in the index of refraction between silicon and air, which results in a reflection at the silicon-air interface. For infrared lenses this is mitigated with antireflection coatings. Usually it isn't necessary to coat silicon samples, though it could improve signal by as much as 50%. However it takes special equipment to do it correctly. The InfraScope operates in the mid-wave infrared (MWIR) band, usually given as 2 to 5 microns. At these wavelengths it is quite easy to see through the backside of the die or wafer for backside inspection for undoped to moderately doped silicon.



2.6 Useful Take-Away Points

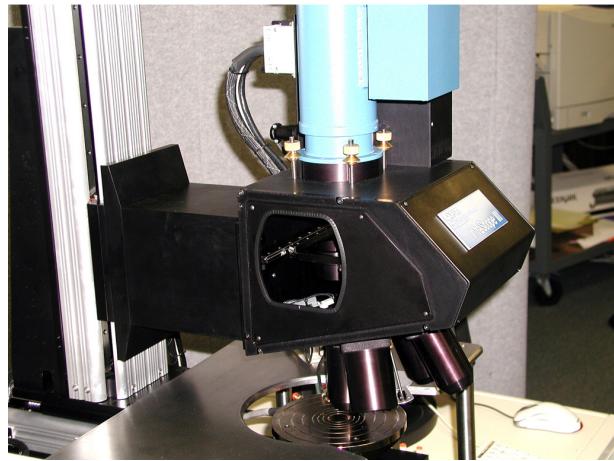
- Infrared techniques detect photons resulting from heat.
- The infrared photonic signature from a hot spot is a cubic function of Kelvin temperature. Using higher base (thermal stage) temperatures will improve the signal to noise ratio.
- Metals are less emissive than other materials and gold more so than other metals. When measuring parts with quite a lot of gold, it helps to use a higher stage temperature. In some cases it may be necessary to coat the sample with black paint or to dust it with talcum powder to raise the surface emissivity.

3 InfraScope Models

The InfraScope has evolved through many models over the years. Currently the following InfraScope models are commonly in use and are supported by QFI.

3.1 InfraScope 3

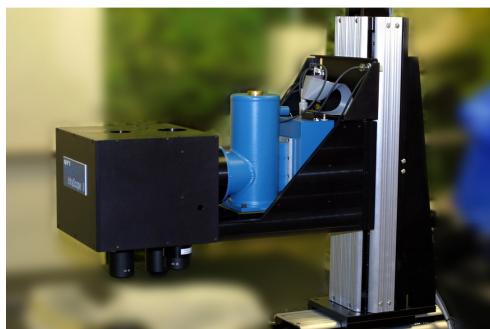
It may be used for thermal mapping or hot spot detection. It has a down-looking infrared camera and a domed lens turret. It may be equipped with optional automated lens motion.



InfraScope 3

3.2 InfraScope II

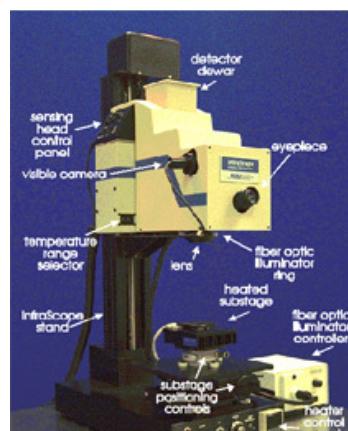
The InfraScope II is employed for both thermal mapping and hot spot detection but it is optimized for thermal mapping. The InfraScope II lenses have large working distances to facilitate probing and large device packages.



InfraScope II

3.3 InfraScope I

The InfraScope I was made by Barnes Engineering, QFI's predecessor. QFI has made an electronics, computer and software upgrade available to extend the life of this model. It is the least sensitive and lowest throughput of the InfraScope models but still has good utility for thermal mapping.



4 Normal Operation

This chapter covers routine operation of the InfraScope. It discusses some of the reasoning behind the commands described in more detail in the Software Menu Section.

4.1 Basic Setup

4.1.1 Vibration Isolation

Like any microscope, and perhaps more so than many, the InfraScope measurements are degraded by vibration. The InfraScope should be mounted on a vibration isolation table. Before beginning a measurement check for proper floating of the table. Also check for unwanted linkages between the isolated and non-isolated parts of the set up. Electrical cables or fluid hoses may couple vibration to the isolated setup. If they do, try looping the cables and fastening with masking tape. Vibration will reduce system spatial resolution and it will ruin the careful alignment of the pixel-by-pixel emissivity correction to the live image.

4.1.2 Air Currents – Air Conditioning

The InfraScope is sensitive to thermal air currents. The InfraScope should be employed in a laboratory environment that is not subject to extremes of heat or cold. It should be located away from air registers or duct outlets.

4.2 Liquid Nitrogen (LN2)

The infrared detector must be operated at cryogenic temperature. It cannot detect infrared radiation if it is not cooled, however the detector will not be harmed if powered without the LN2. Before using the InfraScope, fill the infrared dewar with liquid nitrogen using the supplied funnel. Don't lose the metal stem on the funnel; it lets the LN2 flow below the vigorous boiling that occurs at the surface. The dewar typically holds 300 ml of LN2 but it will require perhaps a liter or more for initial cool down and filling. A full dewar with a good vacuum should last more than 8 hours. If a dewar will not stay cold for at least 4 hours the dewar should be repumped. See the Maintenance and Calibration section for details

The dewar should be partly filled, perhaps a third or half, then allowed to boil and vent for a few minutes before completely filling. Otherwise the gaseous violence inside the dewar will prevent complete filling. The dewar should be filled until LN2 dribbles gently from the top of the dewar. Give the InfraScope some minutes to stabilize after filling with LN2.

Liquid nitrogen is extremely cold and with prolonged contact it can damage skin and eyes. Never make an airtight seal on your transfer vessel. In a closed system LN2 can expand to tens of thousands of PSI, well beyond capacity of common containers to resist exploding. LN2 expands 696:1 by volume from liquid to gas. **Observe your organization's safety practices for handling liquid nitrogen.** QFI does not recommend gloves for handling LN2. We dislike the loss of control and handling coordination caused by gloves and we worry about trapping LN2 between the gloves and skin. LN2 has very little heat capacity and occasional spatter has almost no effect on skin other

		11 of 70	www.quantumfocus.com Quantum Focus Instruments Corp, Vista, CA USA
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than slight tingling. LN2 is safe to handle when modest precautions are observed. For example LN2 is much safer to handle than is scalding water.

4.3 Sample Preparation

4.3.1 Decapsulation

The InfraScope cannot see through most materials. The user must expose the surface that he wishes to measure.

4.3.2 Sample Mounting

The sample must be carefully fixed to the thermal stage. It must not creep or move. The InfraScope performs mathematical operations on each pixel between sequential captured images. If the sample moves, even slightly between sequential images, the measurement will be spoiled. We strongly recommend using the threaded holes on the thermal stages for fixing the sample. Any wires attached to the sample should have a relief loop and be taped to the stage or table to prevent tugging.

4.3.3 Sample Heating for True Temperature Measurements

The InfraScope measures emissivity at each pixel location and uses this value in subsequent measurements to accurately measure temperature. To calculate emissivity, the InfraScope algorithm must know the temperature of the sample surface during the Reference measurement, before the device is powered up. If the device is thin and well sunk to the thermal stage the InfraScope can use the thermal sensor built into the thermal stage. Examples are a device in wafer form, or a thin flat package with a conductive base. Samples with poor thermal contact to the thermal stage should be instrumented separately with thermo-couples or other means to accurately measure the unpowered surface temperature. Unwieldy samples that cannot be fitted with temperature sensors should be painted black.

4.3.4 Sample Heating for Failure Analysis detection of Short Circuits

The most powerful techniques for hot spot detection require emissivity compensation, which requires knowing the unpowered surface temperature during the Radiance Reference acquisition. This is best done as outlined above, however imperfect knowledge of the surface temperature may not impair the hot spot detection. The final temperatures may not be accurate but the hot spot may still be detectable. Therefore imperfect knowledge of the surface temperature may be tolerable for hot spot detection.

4.3.5 Sample Heating for Improved Sensitivity

The photons emitted from a surface increase as a cubic function with absolute temperature. Therefore, a 1 degree rise at 50 C will carry many more photons than a 1 degree rise at 20 C. This means the InfraScope sensitivity is improved with increasing sample temperature. Too much sample temperature creates convection air currents that disturb the measurement. Convection air currents are those shimmering currents seen rising from the hood of a hot car in the summer. For thermal mapping, the best stage temperature is about 70 Celsius. For hot spot detection much lower temperatures may be suitable.

	12 of 70	www.quantumfocus.com Quantum Focus Instruments Corp, Vista, CA USA
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4.4 Sample Placement

Set the stage temperature to 50° C or lower before touching stage. Mount the sample to the heater stage using an appropriate fixture. Make sure that the fixture is mounted securely. Also make sure that a good thermal contact is established between the sample, the fixture and the heater stage. When the sample is mounted securely set the stage to the desired temperature. We suggest 70° to 80° C.

4.5 Initial Focusing and Sample Centering

Select the low magnification lens using the Lens Turret tab. This is the default choice at power up. Select “R_{ref}” from the “Acquire” tab. Move the optical head in X, Y and Z until the image is centered and focused. On some InfraScope configurations the X-Y-Z motion may be manual, other configurations may have a joy stick or button box, and still others use a software motion control applet.

4.6 Changing Lenses

Select the desired lens using the Lens Turret tab. This sets the appropriate and required calibration tables and invokes the assisted par-centering and par-focusing on appropriate configurations. Follow the software prompts.

Finish the focusing and centering with the button box.

NOTE: The software par focusing moves the head an appropriate distance to par focus the new lens. This assumes that the InfraScope was in focus at the preceding lens. If the InfraScope is not in focus before changing lenses then when the InfraScope moves to focus the next lens it may crash into the sample. Always start by focusing the system with the low magnification lens. If that isn't possible, refuse the par-focusing assistance when prompted by the software and focus manually.

4.7 True Temperature Thermal Mapping

The temperature measurement is comprised of three user steps:

First: acquire an unpowered Radiance Reference image, used to find and map the sample emissivity at each pixel (R_{ref} Button).

Second: acquire an unpowered temperature image to check the set-up (T₁₋₄ Button). (The user can simply examine the live unpowered temperature image without capturing it if desired.)

Third: take a powered temperature image to record the powered device true temperature.

This sequence typically takes 10 to 20 seconds to complete.

4.7.1 R_{ref} - Radiance Reference



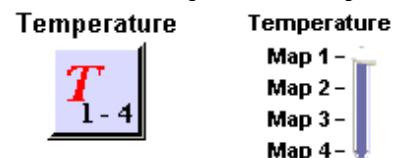
All measurement sequences start with the unpowered R_{ref}. The R_{ref} values are accurate, calibrated radiance units measuring the infrared radiation given by each pixel area of the sample. Once acquired, the R_{ref} image is instantly processed to produce an emissivity map. The emissivity map is used on each of the subsequent powered temperature images so it is wise to proceed immediately to

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the temperature acquisitions. If too much time elapses conditions may change unacceptably, (such as minute sample motion).

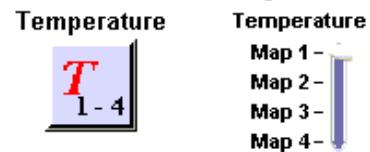
To acquire R_{ref} , press the R_{ref} button. A live R_{ref} image will appear. Press the “stop” button to store the R_{ref} image to system memory.

4.7.2 T_{1-4} Unpowered Temperature image



Next, before powering the device, the operator should examine an unpowered temperature image by pressing T_{1-4} . This launches a live temperature image. If the emissivity correction is effective, and if there is no vibration, air convection or other mechanical disturbance the image should be uniform and the temperature spread within a few degrees, peak to peak or a few tenths, RMS. The unpowered temperature image reveals the goodness of the setup and serves as a predictor for the accuracy of the powered temperature measurement. Use judgment here. If a solder bond shows up, or a spot appears outside the area of interest it may be ignored. However often a poor setup will reveal systematic flaws. For example, tugging wires on the device will slowly move the part in one direction, mislocating the emissivity map on one axis only. This will result in complementary too-hot and too-cold edges (red and blue edges) at abrupt transitions like metal lines, and only orthogonal to the pulled axis. Use the unpowered temperature image to perfect the set-up. With a little practice you will become very good at this.

4.7.3 Powered Temperature Image T_{1-4}



When satisfied that the setup is sound, you acquire the unpowered image to memory by pressing the ‘Stop’ button, or if you prefer you may apply power to the device and acquire the powered image. Pressing the ‘stop’ button saves an image to a memory buffer as part of the measurement ‘job’. The job can be saved to disk for future review. The user can store up to 4 temperature images in separate buffers by using the Map 1 through Map 4 switch seen above. Users frequently use the buffers to store a temperature image for different current conditions.

4.7.4 Adjusting the Range



Sometimes the powered temperature exceeds the range of the InfraScope. This will be apparent during the live temperature image as the affected pixels will display grey with no value. If you see grey pixels in the area of interest, press the “RANGE” button and choose the next higher temperature range. The InfraScope will automatically retake the image at the higher temperature range. See the description of the RANGE control for a description of this function.

4.8 Delta Radiance Fault Isolation Method

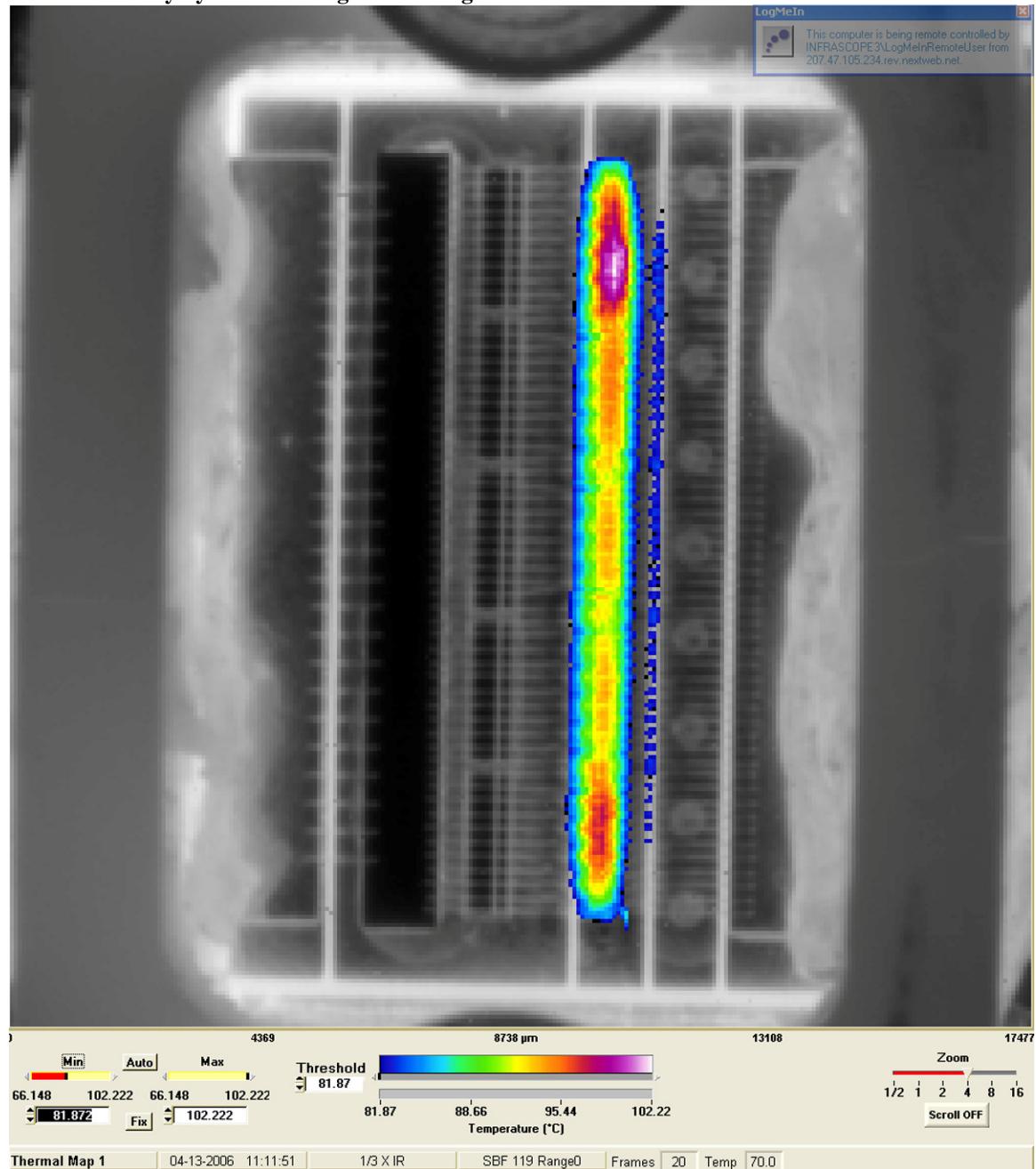
This function is used for fault isolation for failure analysis. The technique subtracts an unpowered radiance image from a powered radiance image.

Acquire R_{ref} per the preceding methods.

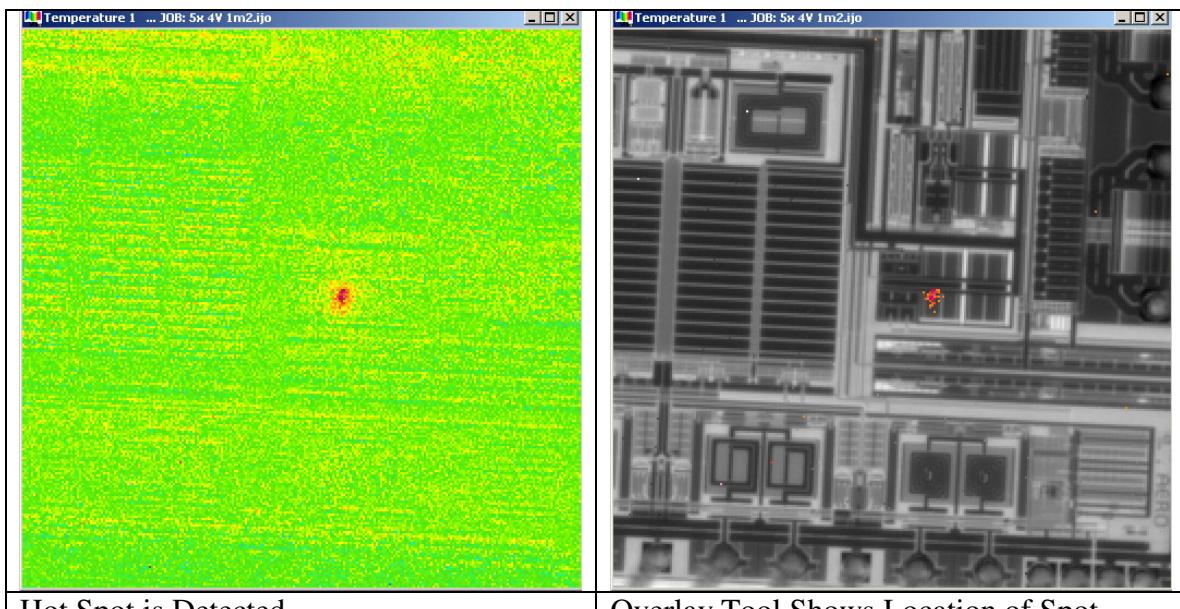
Press the R_Δ button and power the device.

4.9 Image Overlay

4.9.1 Overlay by Thresholding and Scaling



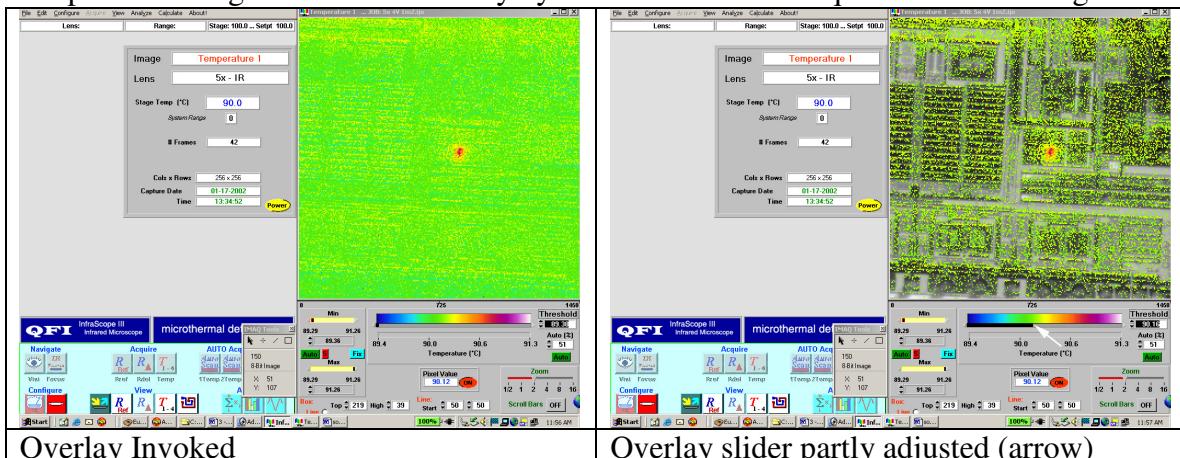
	15 of 70	www.quantumfocus.com Quantum Focus Instruments Corp, Vista, CA USA
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Hot Spot is Detected

Overlay Tool Shows Location of Spot

Use the overlay function to reveal the location of hot areas. The overlay uses a monochrome view of the unpowered Radiance Reference image with the desired Temperature, Delta Temperature, Delta Radiances, or Radiance Movie Frame perfectly overlaid and perfectly registered. After capturing a temperature image reveal the underlay by one of several techniques. One is to drag a threshold

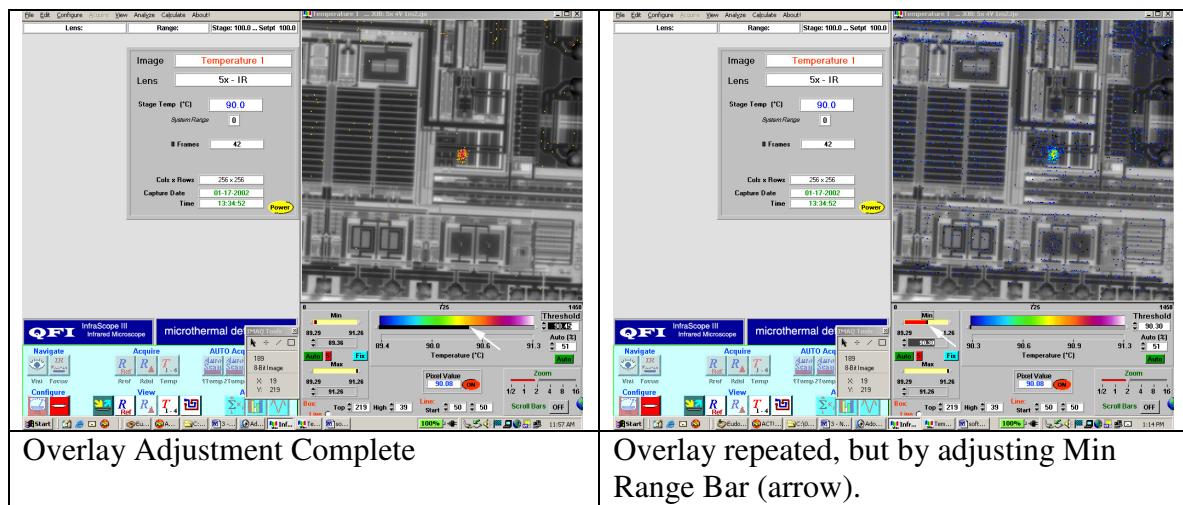


Overlay Invoked

Overlay slider partly adjusted (arrow)

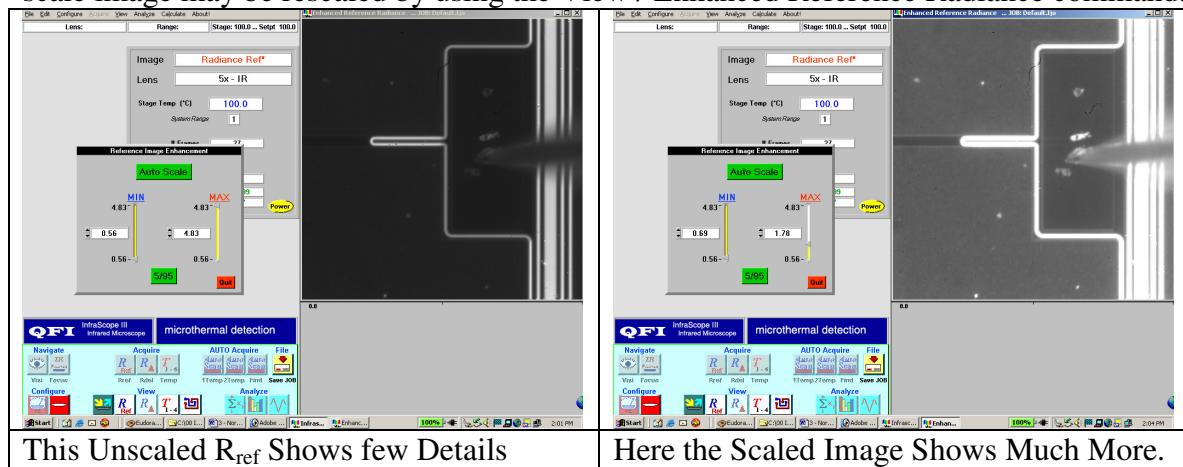
bar just under the temperature scale (see example). Alternately, and with somewhat different results, the overlay may be stripped from the underlay by adjusting the manual scaling. In the example the minimum was adjusted to remove temperatures less than that of the desired spot. Note that this affects the displayed colors and sometimes makes it easier to pinpoint the hot area.





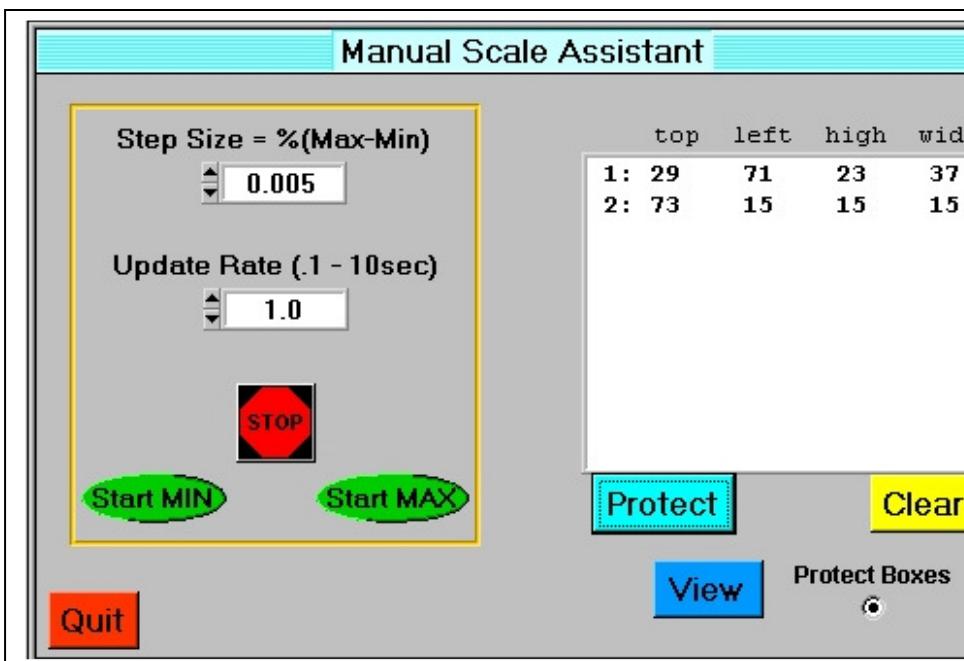
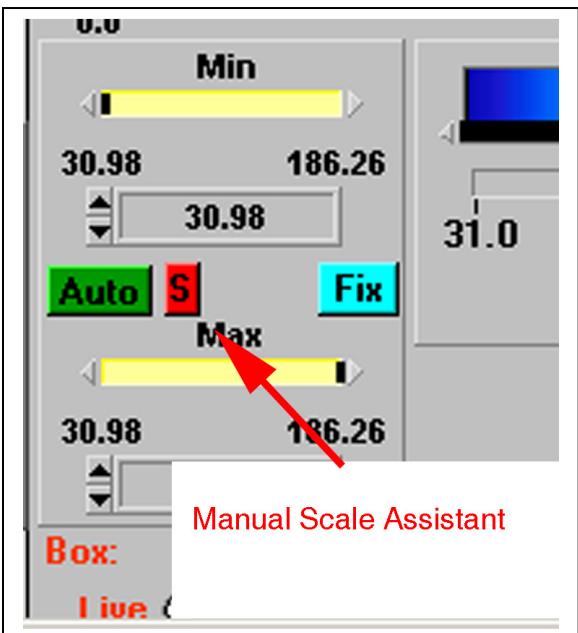
4.9.2 Enhanced Reference Image

All 12 or 14 bit InfraScope images are scaled for display to the brightest and darkest pixel. In some cases, especially for backside images, this results in an image scaled to include a single bright and sometimes unimportant area, but with little gray scale or color detail for the region of interest. The scaling controls used in the previous overlay example serve to rescale color images. The InfraScope software also includes scaling tools to improve the Underlay Radiance Reference image. The gray scale image may be rescaled by using the View / Enhanced Reference Radiance command.



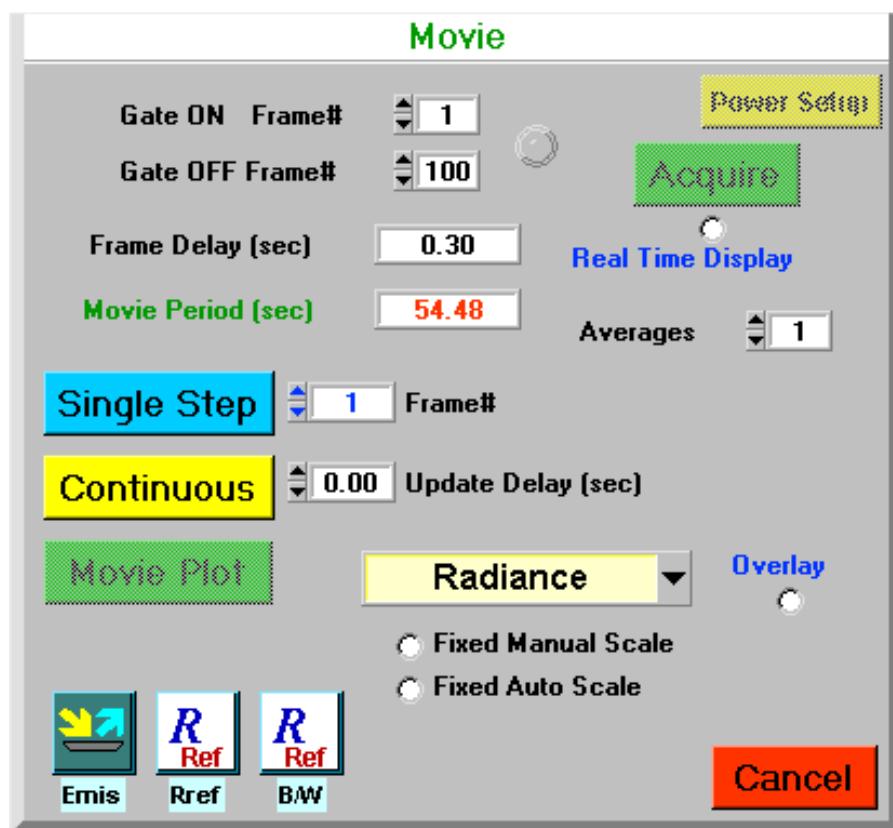
4.9.3 Manual Scale Assistant

The InfraScope includes a Manual Scale Assistant for overlaying, thresholding and selectively protecting areas of the image. For details see the Software Menu portion of the manual, under Image Information & Adjustment Regions.



4.10 Movies

The movie mode captures 100 sequential frames of Radiance or Temperature images. They may be captured as quickly as possible, or the user may insert a frame delay to capture a Time Lapse movie over a long interval. With the controllable power supply option; movies may also be captured as a



function of varying power to the sample. The speed of acquisition usually is limited by the processor speed and the size of the infrared detector array. For details on acquiring and displaying movies, please see the Software Menu chapter.

4.11 Saving the job

Save the job as full 12 bit or more data by choosing from the menu, File, Job, Save. After thousands of measurements in our own lab, we have adopted the convention of creating a folder with a descriptive name (e.g., serial number) for each separate part, and storing in that folder jobs designated with 1x, 5x, or 15x for the magnification, plus other descriptive information about the measurement such as the volts and current employed.

4.12 Exporting the Data

There are 2 methods for exporting screen images from the InfraScope, direct TIF, BMP and PNG image exports from InfraScope, and exports to any file format via Paint Shop Pro.

4.12.1 Exporting with Paint Shop Pro

Every InfraScope is shipped with a copy of Paint Shop Pro photo editing software. The best way to export images from the InfraScope is to capture the screen image to the Windows clipboard, and then paste it into Paint Shop Pro. Then crop, annotate or adjust the image to taste and export it as a JPEG or any of 32 image formats.

Procedure:

Press the Print Screen button on the keyboard to copy the entire display to the Windows clipboard.

Open **Jasc Software Paint Shop Pro** either from Windows Start Program menu or from InfraScope File / Image Editor menu.

In Paint Shop Pro, use Edit / Paste to paste the clipboard contents as a new image. Use the tools to crop the desired area, for example the image plus the color temperature bar. If desired, annotate the image with contrasting colored arrows and text.

Use File / Save Copy As and choose an appropriate file format, e.g. *.jpg.

It is possible to copy only the image window in InfraScope to the clipboard by clicking once in the image window, and then holding the ALT key while pressing Print Screen. This works for any windows application, and copies only the active window.

4.12.2 Exporting directly from InfraScope

Export only the displayed InfraScope image directly from InfraScope by choosing “File / Save Image Formats” from the InfraScope menu. Choices are TIF, BMP, PNG and TXT. The txt option exports a huge text file giving the ASCII value of every pixel in the image in a 256x256 or greater array. The units will be those of the image, e.g., temperature, radiance or emissivity. The ASCII output is handy to give to the finite element analysis guy.

4.13 Manual Temperature Control

All radiance and temperature measurements can be done using an external heated source, temperature controller or the provided controller under local (rather than remote) control. To select this alternative, check “External Stage Temperature Control” in the “Stage Temperature” window. Using this method, you will be asked to enter a stage temperature at the end of each requested acquisition.

4.14 Using the anti-convection Fan

Since 2001 InfraScopes for thermal mapping have been shipped with a small muffin fan mounted on a microphone stand. This fan servers several purposes and should be placed to create a gentle room ambient temperature airflow that touches both the sample and the current infrared objective lens.

4.14.1 Maintains Thermal Accuracy

The anti-convection fan prevents heating of lenses from hot sample stages. The lens has a small but significant radiation contribution of its own. Keeping the lens at lab temperatures will ensure the

		20 of 70	www.quantumfocus.com Quantum Focus Instruments Corp, Vista, CA USA
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accuracy of the InfraScope. Higher magnification lenses make a greater error contribution, so it is more important to keep high magnification lenses at lab temperature.

4.14.2 Anti-Convection

Hot sample stages produce heat waves in the air much as we see from the hood of a car in the hot sun. The hot air currents disturb the image and look much as though someone were shaking the InfraScope. These effects tend to be most obvious above about 65 Celsius. The fan sweeps these air currents away at the device before they rise to disturb the image. In most cases the fan will not affect the surface temperature of a well sunk device. This may be confirmed by blocking the fan with your hand while taking a live temperature image. Note that in the presence of convection, transition edges will be immediately adversely effected by removal of the fan, but large planar areas will not be.

5 InfraScope Software Description

5.1 Software Introduction

This chapter describes the functions provided by the InfraScope software interface.

5.2 Launch & Initialization



The InfraScope system software is launched by clicking on the desktop shortcut icon shown above or by selecting the InfraScope program from the Windows start button menu. After launching, the system performs a series of initializations and diagnostics with each being tracked and reported within an initialization panel. If any initialization step fails, the user will be presented with a **Retry/Skip/Quit** option panel. **Retry** attempts to re-execute that particular initialization step. **Skip** bypasses the step (this will disable some functionality with the system but allow the program to proceed). **Quit** terminates the program. Upon completion of the initialization sequence, a dialog box beside the System Initialization panel will prompt the user to acknowledge the system is ready. After clicking OK, the InfraScope system Main Menu is available.

5.2.1 Headmaster

The InfraScope software will launch an auxiliary program called Headmaster if it isn't already running. Headmaster is usually invisible to the user. The QFI optical head may have more than one Fault Isolation sensor installed. The job of Headmaster is to control the optical head functions, such as switching lenses and internal optics that are common to all of the sensors. When Headmaster starts it will initialize all of the stages in the optical head. When the InfraScope software is stopped, Headmaster continues to run invisibly so that head is initialized and instantly ready to go when called by the emmi, LSIM or InfraScope Hot Spot software. For diagnostics, headmaster can be accessed from the Windows icon tray in the lower right of the windows task bar.

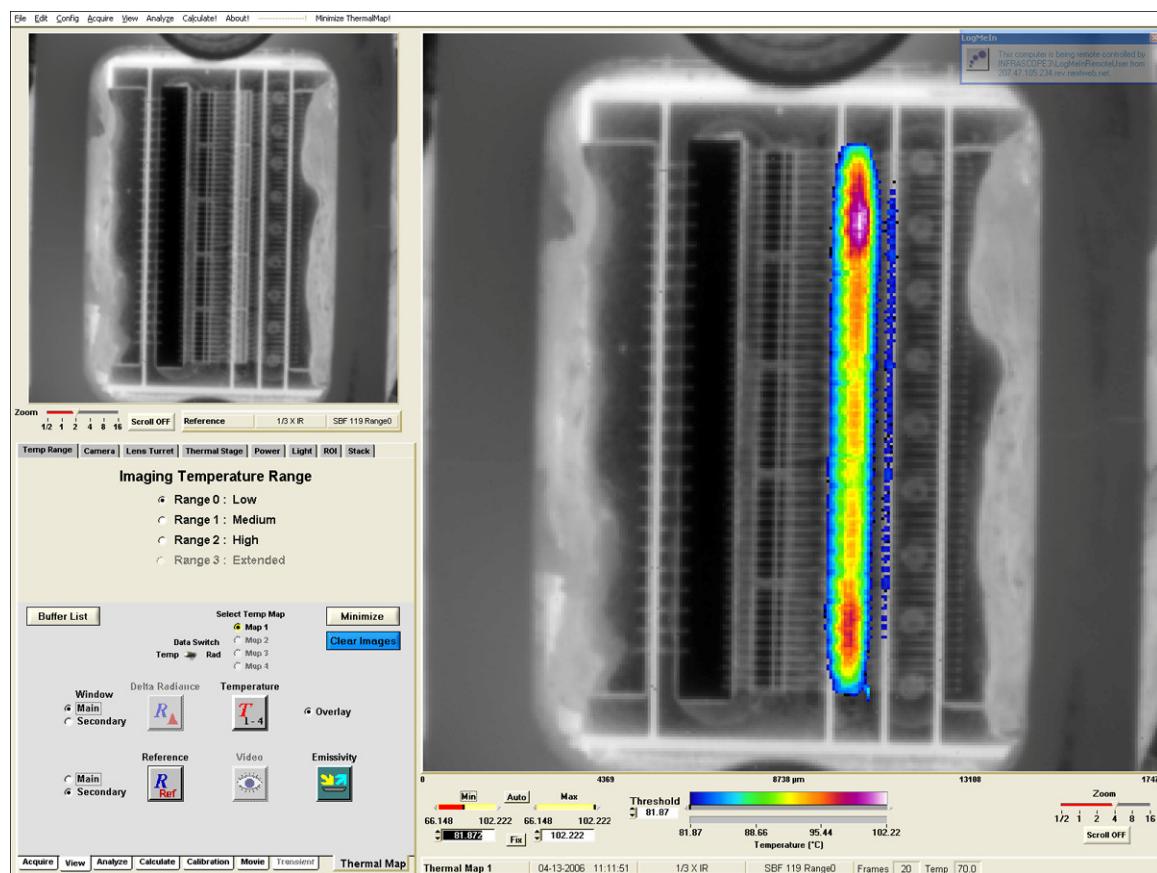
The logo consists of the letters "QFI" in a white, bold, sans-serif font, enclosed within a dark blue rounded rectangle.		21 of 70	www.quantumfocus.com Quantum Focus Instruments Corp, Vista, CA USA
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5.2.2 Stagemaster

If your InfraScope is equipped with a thermal stage then InfraScope software will launch an auxiliary program called Stagemaster. Stagemaster also runs invisibly to the user. The job of Stagemaster is to coordinate the thermal stage control functions as needed by the installed fault isolation sensors. When the InfraScope software is stopped, Stagemaster continues to run invisibly so that it is instantly ready to go when called by the emmi, LSIM or InfraScope Hot Spot software. For diagnostics, Stagemaster can be accessed from the Windows icon tray in the lower right of the windows task bar.

5.3 Main Screen Menu

The InfraScope user interface provides a Windows environment for infrared imaging analysis. The user is provided with a powerful set of display, acquisition and data manipulation features. The InfraScope Main Menu screen is illustrated below.



5.4 Tabbed Commands

The InfraScope user interface provides a Windows environment for microthermal mapping. The user is provided with a powerful set of display, acquisition and data manipulation

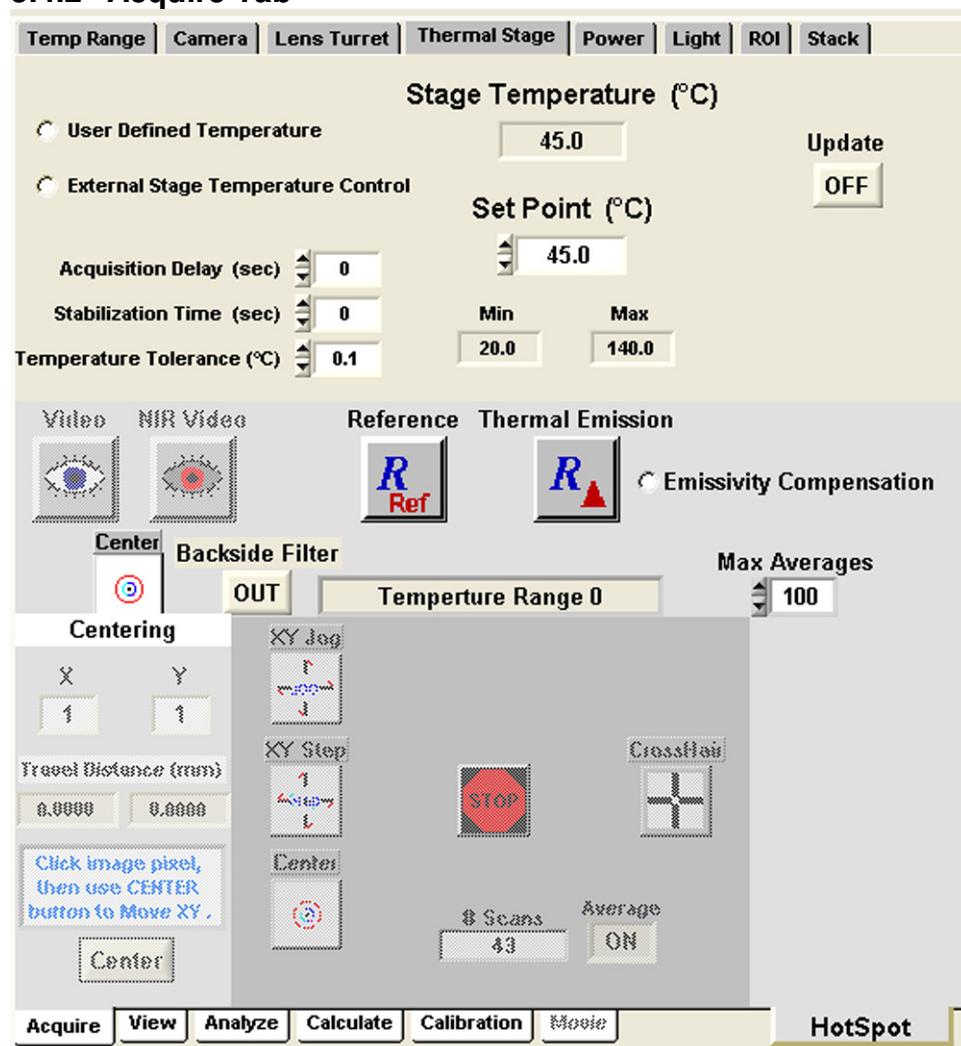
	22 of 70	www.quantumfocus.com Quantum Focus Instruments Corp, Vista, CA USA
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features. A typical InfraScope screen is shown above. InfraScope software controls are located in the tabbed control panel in the lower left.

5.4.1 Typical Sequence of Use

The user may start with the small video camera or the infrared camera for setting probes and navigating around the die. When satisfied, the user powers-off the device and acquires a reference image from the infrared camera. The reference image is a calibrated, pixel-by-pixel capture radiance variation of the unpowered die and it is usually a crucial part of the measurement sequence. Since every part of the die is at the same temperature, the image contrast is all due to material property differences, specifically emissivity. The Reference image is used by the algorithms to compute the emissivity differences at each pixel and by compensating to the emissivity the algorithms compute the final die temperature. The Reference image also serves as a monochrome underlay image which may be used to locate the hot features later. The user then powers the sample and takes a temperature image.

5.4.2 Acquire Tab



The acquire menu is available from the lower set of tabs as shown.

5.4.2.1 Video

The Video button acquires real time video from the navigation and probing camera. The image appears on the computer monitor and is also available on the LCD video display that is mounted on the optical head. The video image is commonly used for focusing and centering the optical head, and for setting microprobes on the die. The user should also adjust the light intensity for appropriate illumination from the [Light tab](#) (upper row) when using this function.

5.4.2.2 NIR Video

Grayed out unless the InfraScope is equipped with an optional NIR navigation camera. The NIR camera is used for inspection, centering and focusing for backside applications, that is, looking through the silicon on the back of the die. It operates much like the Video camera except it has NIR response and is capable of viewing through silicon. The user should also

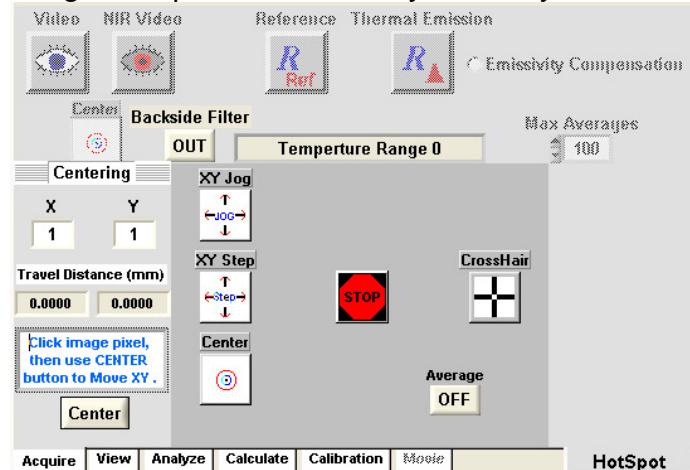
adjust the light intensity for appropriate illumination from the [Light tab](#) (upper row) when using this function.

5.4.2.3 Reference

Reference Thermal Emission



This function is associated with the infrared camera. The R_{ref} button acquires a monochrome infrared reference image of the unpowered device. All of the image contrast is due to the emissivity properties of the sample materials and the source of infrared light is the sample itself, from the ambient heat of the part. The R_{ref} image is used as a reference underlay to show the location of the hot spot. It is also used to calculate the sample material properties pixel by pixel so that the emissivity compensated image will appear flat and featureless except for the hot spot. The user must capture an R_{ref} image before capturing an R_{Δ} image. The image is live until the stop button is pressed. At that point the image is captured to memory and may be subsequently used and saved.



Press the Stop button to capture a live image to memory.

5.4.2.4 Thermal Hot spot

Reference Thermal Emission



R_{Δ} acquires the hot spot image. Power should be applied to the device under test before or while acquiring the live R_{Δ} image. If the Emissivity Compensation radio button is not checked, the R_{Δ} image will perform a simple image subtraction between the powered R_{Δ} image and the unpowered R_{ref} image. If the Emissivity Compensation radio button is checked, then the InfraScope software will perform a pixel by pixel emissivity compensation algorithm before displaying the hot spot. It is difficult to predict in advance which method will be better for detecting a hot spot, however the author of this manual strongly prefers the emissivity compensated method. This image is live until the stop button is depressed, so the user may cycle the power to the device to look for subtle changes.

	25 of 70	www.quantumfocus.com Quantum Focus Instruments Corp, Vista, CA USA
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5.4.2.5 Center

When an hot spot is located, the user may center the hot spot in the field of view with the Centering function. This is useful just before increasing lens magnification. Pressing the Center button enables the Centering menu. The user then clicks on the desired location in the image area, and presses the lower Center button to perform the centering action. It is always prudent to verify that the feature or hot spot is centered by acquiring a new image before changing lenses.

5.4.2.6 Backside Filter

Not implemented in the InfraScope

5.4.2.7 Temperature Range

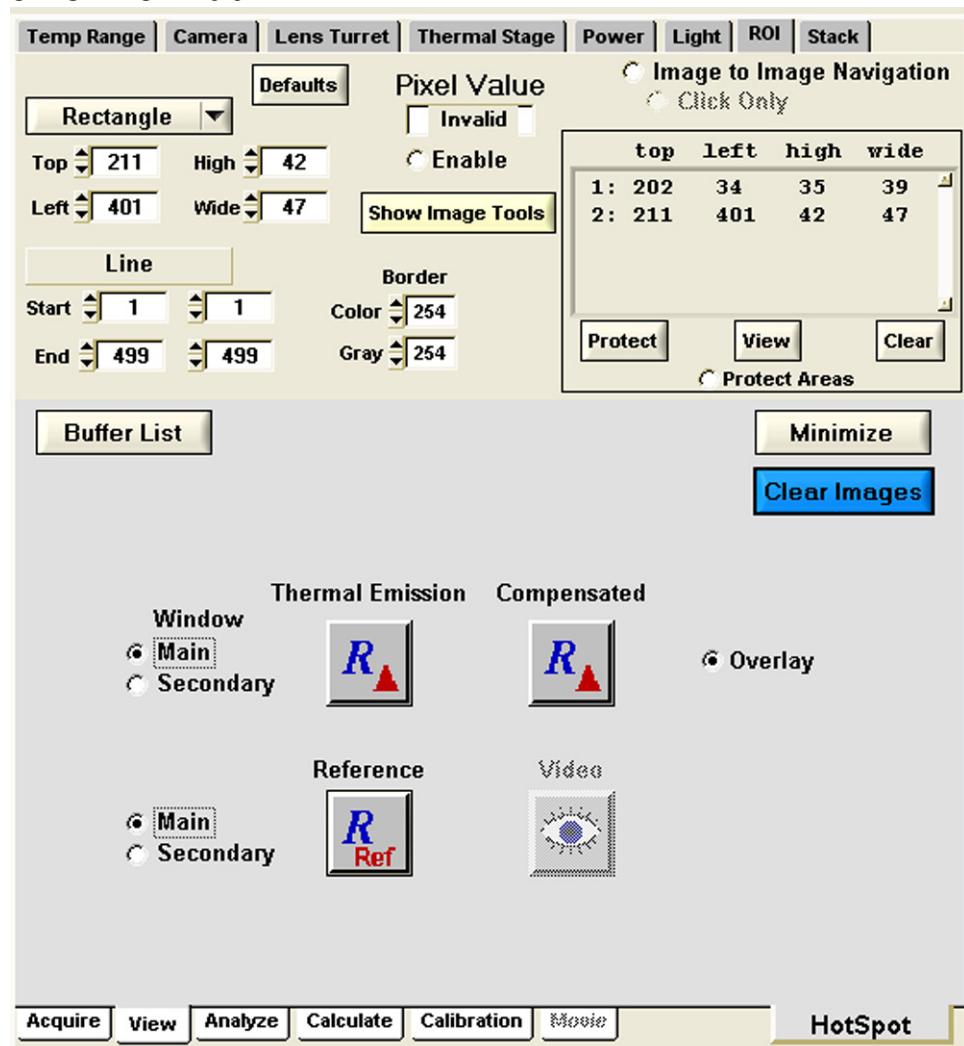
The InfraScope Hot Spot detector has 2 or more temperature ranges. Range 0 is the default range and it offers the most sensitivity for detecting faint hot spots. In some cases some unusually high temperatures will saturate the detector with too many photons. In those cases the measurement range may be increased to extend the dynamic range of the InfraScope.

5.4.2.8 Max Averages

The user may opt to average some image frames together to improve signal to noise or to improve image cosmetics. The user may limit the number of frames averaged with this control.



5.4.3 View Tab



5.4.3.1 View Tab Overview

View menu is used to display and manipulate the captured or stored images.

5.4.3.2 Buffer List

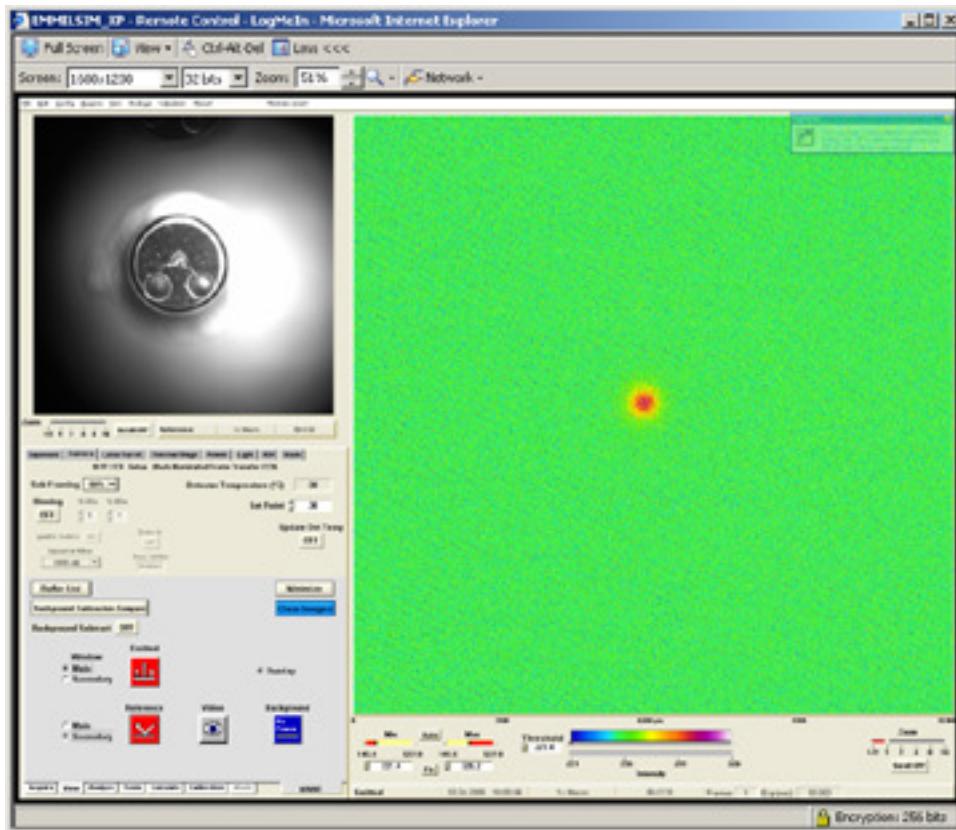
This function shows a table of all images collected and associated with the current job in memory. If the job has been saved the associated name, size and location are given.

5.4.3.3 Clear Images

Clears all image buffers from memory.

5.4.3.4 Thermal Emission Button

This function displays the captured Hot Spot image in the selected main or secondary window. This button displays the R_{Δ} image that does not have emissivity compensation.



Example of hot spot from 2N222 Transistor displayed in main window. If a reference image has been captured it will automatically display in the secondary window.

5.4.3.5 Compensated Button

This function displays the captured Hot Spot image in the selected main or secondary window. This button displays the R_{Δ} image that **does** have emissivity compensation.

5.4.3.6 Overlay, Min and Max level & Color Bar

When overlay is checked, the hot spot image is displayed as an opaque color overlay over the monochrome reference image. The underlying reference image may be exposed by selectively removing the lower values in the hot spot image. This may be done by adjusting the minimum level (see illustration) to remove the low values, or by dragging the black threshold bar just below the color bar or by inserting a threshold number in the indicated box. In some cases the user can make the hot spot "pop" by adjusting the maximum level as in the example.



Emitted

02-24-2005 18:00:56

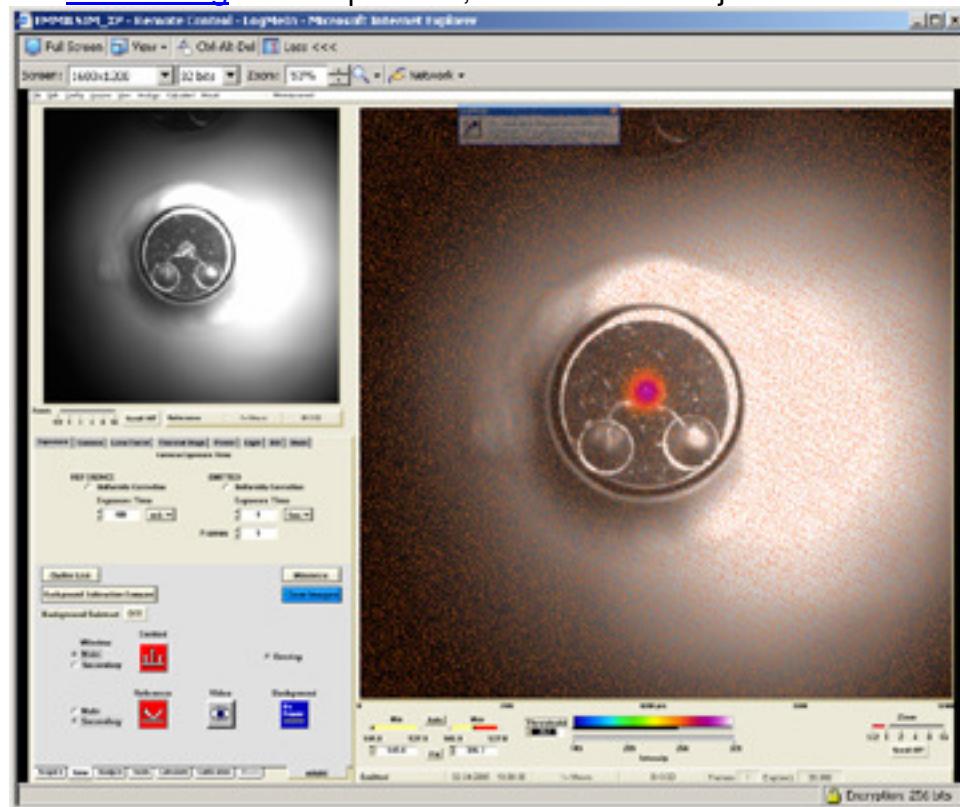
Ex Macro

BI-CCD

Frames 1



The level can be reset by pressing 'Auto' or by dragging the bar back to the right or left as appropriate or by typing an appropriate number into the number boxes. Both the level and the Threshold may need to be adjusted. The 'Fix' button stops the software from performing live autoscaling. When pressed, the user must adjust the levels to suit the image content.



Example of overlaid hot spot on the reference image for a 2N2222 transistor.

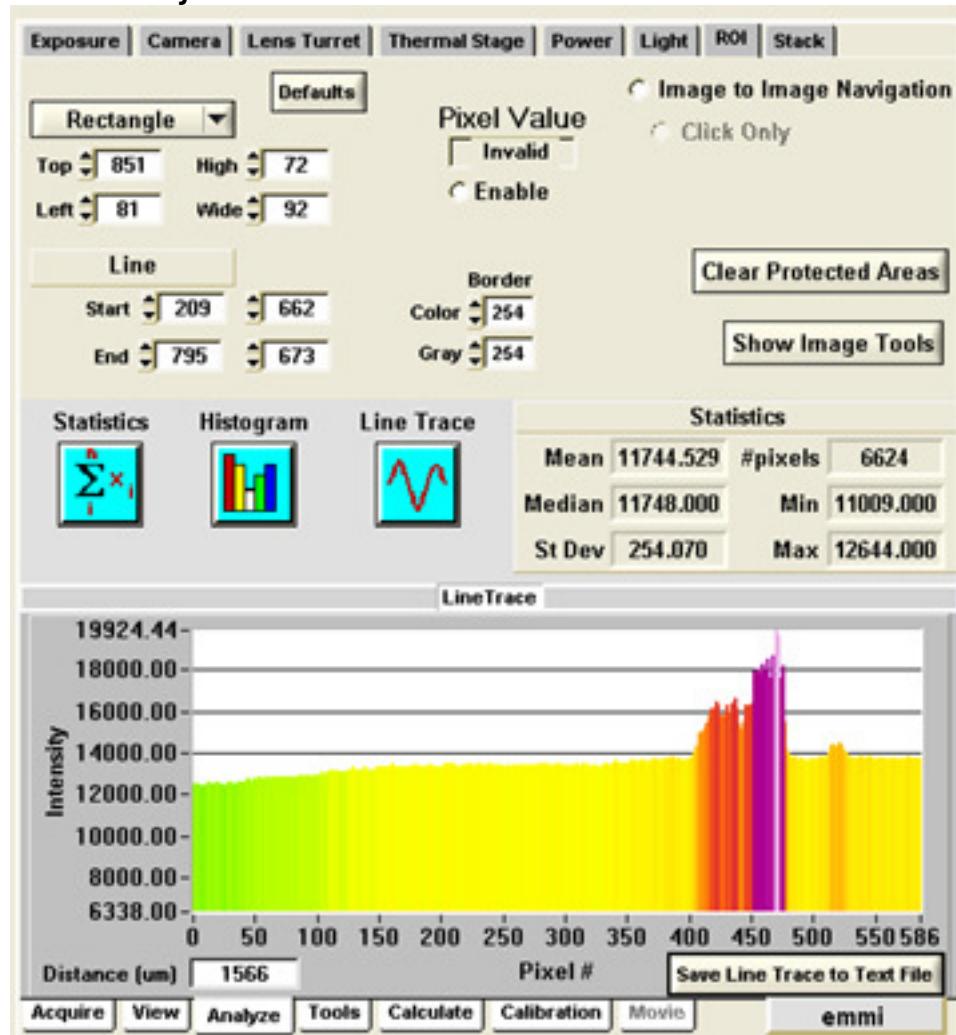
5.4.3.7 Reference Button

This function displays the captured reference image in the selected main or secondary window. The default position is the secondary window.

5.4.3.8 Video Button

This function displays the captured video image in the main window.

5.4.4 Analyze Tab



The Analyze tab seen with the ROI tab selected in the upper row of tabs.

5.4.4.1 Overview

The Analyze menu may be used to examine the statistics in the emitted image, or for creating line and histogram graphics.

5.4.4.2 Statistics

As seen in the example, this function gives the mean, median, standard deviation, max and min of the values within the defined Region of Interest (ROI). The user defines a region of interest from the [ROI tab](#) menu or by drawing a box in the image. Tools for drawing lines and boxes are enabled by choosing "Show Image Tools" in the [ROI tab](#) (region of interest).

5.4.4.3 Histogram

This function draws a histogram plot for the defined Region of Interest.

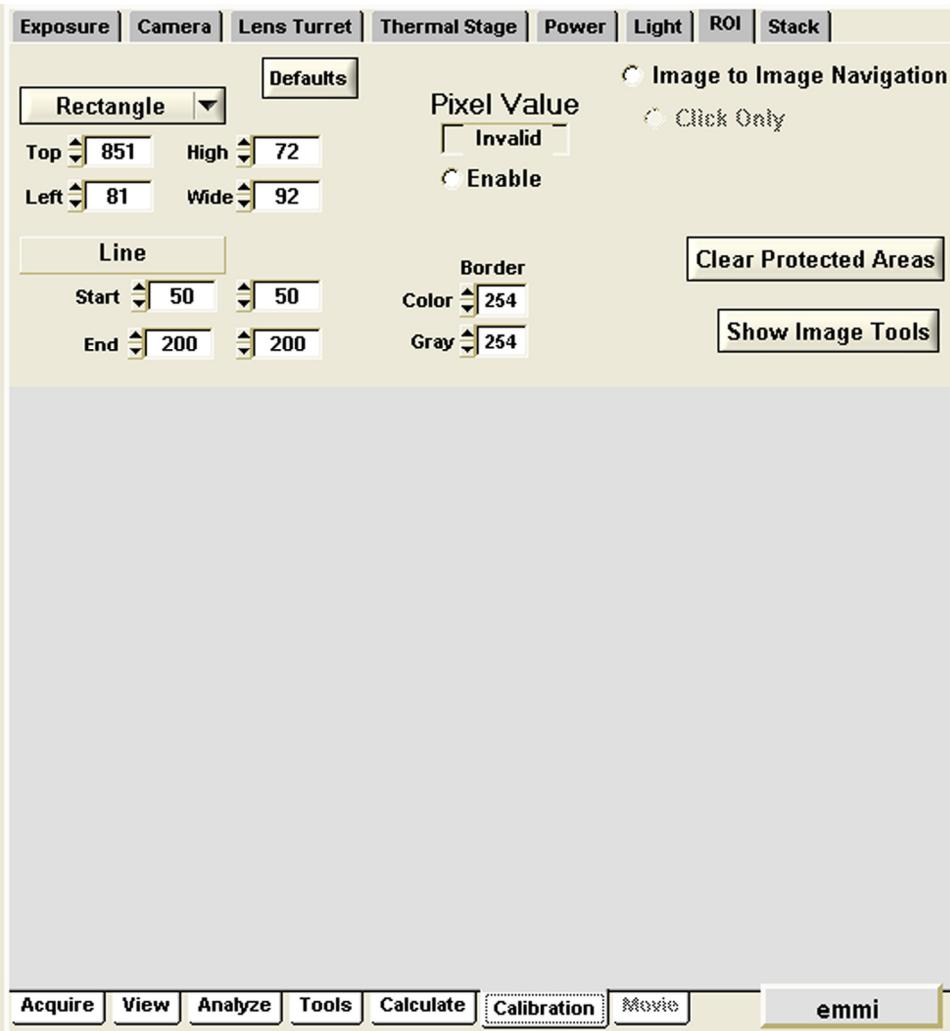
5.4.4.4 Line Trace

As seen in the example, this function plots the pixel values along a user-defined line.

5.4.4.5 Calculate Tab

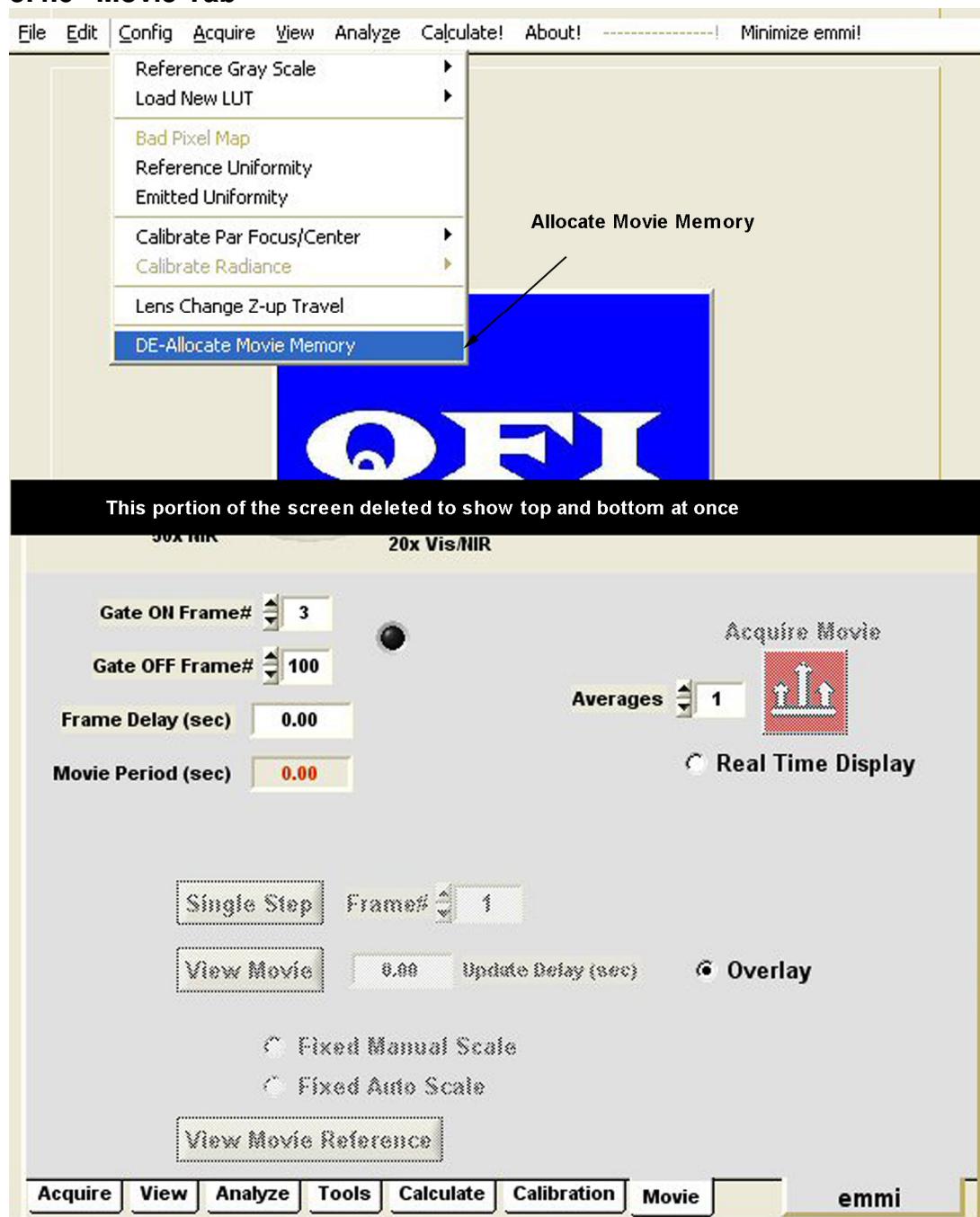
The calculate menu is not used on the InfraScope Hot Spot instrument.

5.4.5 Calibration Tab



The Calibrate Tab is normally blank. If the user accesses the calibration menus from the [Configure Menu](#) at the top of the screen, the menu will appear in this tab. See the [Calibration](#) section.

5.4.6 Movie Tab



5.4.6.1 Overview

The InfraScope Hot Spot software can capture a sequence of 100 images, and then replay them as a movie. In some cases this is useful if the failure signature only appears at a particular current or die temperature. The user sets up the acquisition parameters as usual and then using the Movie Tab, acquires 100 frames. During this interval the user can slowly change a condition such as die temperature. The captured movie can only be viewed with

		32 of 70	www.quantumfocus.com Quantum Focus Instruments Corp, Vista, CA USA
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the InfraScope Hot Spot software, however the user may use screen capture software such as CamMedia to capture and transfer the movie to an AVI format if desired. To use this feature the Movie Memory must be allocated from the [Config Menu](#) as seen in the illustration.

5.4.6.2 Movie Memory (RAM)

The Movie Memory must be allocated from the [Config Menu](#) as seen in the illustration. The size of the movie depends on the size of the detector, but in the case of the 1K x 1K pixel detector, the movie requires about 400Mb of memory.

5.4.6.3 Gate

The InfraScope Hot Spot can output a TTL signal to trigger an external device that may be used to change the conditions during the movie acquisition. If you need this feature, please phone QFI customer service for the location of the output connection for your InfraScope Hot Spot configuration.

5.4.6.4 Frame Delay

If desired the user can insert a delay before each frame is acquired.

5.4.6.5 Viewing the Movie

The user may view the movie in its entirety with the **View Movie** command or by **Single Step**, or at any arbitrary frame by typing in the desired frame number. The overlay function is available by checking the Overlay option and manipulating the levels and threshold as described elsewhere in this manual.

5.4.6.6 Fixed Manual Scale / Fixed Auto Scale

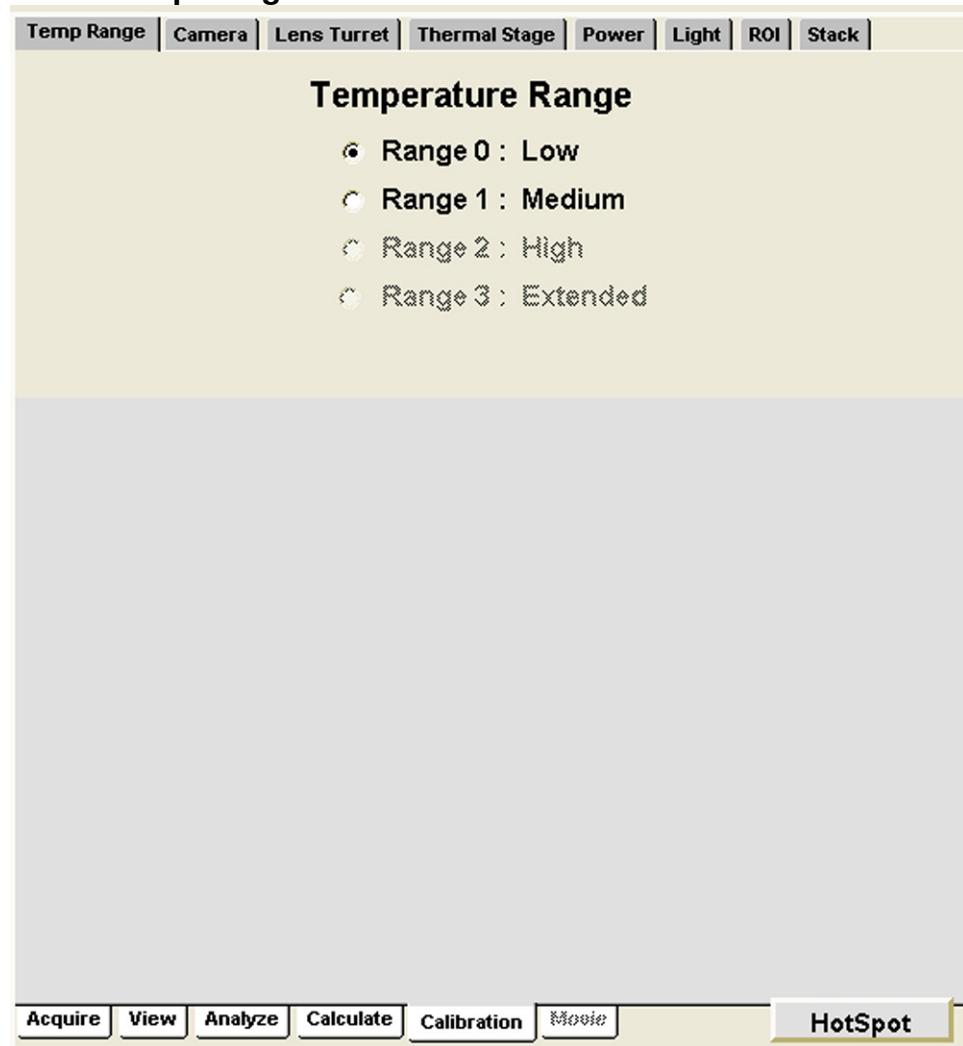
Without intervention each frame will automatically [scale](#) to its own highest and lowest pixel values. For a movie sequence it is often much more useful to scale the image to the highest and lowest value in all 100 frames, or to some other arbitrary value. The **Fixed Auto Scale** option automatically scales to the highest and lowest values in the entire movie. If this doesn't suit, the user may choose **Fixed Manual Scale** and adjust the high and low levels as desired. It is best to start with **Fixed Auto Scale** to preset the image levels to the max and min values, and then adjust them down as desired.

5.4.6.7 Converting the Movie to an AVI

The movies are captured in the native deep bit resolution of the InfraScope Hot Spot detector, and must be replayed by InfraScope Hot Spot software. However QFI ships the InfraScope Hot Spot with a freely distributable open source screen capture utility, **CamStudio** that can easily convert an InfraScope Hot Spot movie to a portable Windows AVI format. Even better, the utility can be used to crop to a particular region of interest and to a particular sequence in time so the resulting AVI will be compact and easily electronically transmitted.

	33 of 70	www.quantumfocus.com Quantum Focus Instruments Corp, Vista, CA USA
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5.4.7 Temp Range Tab

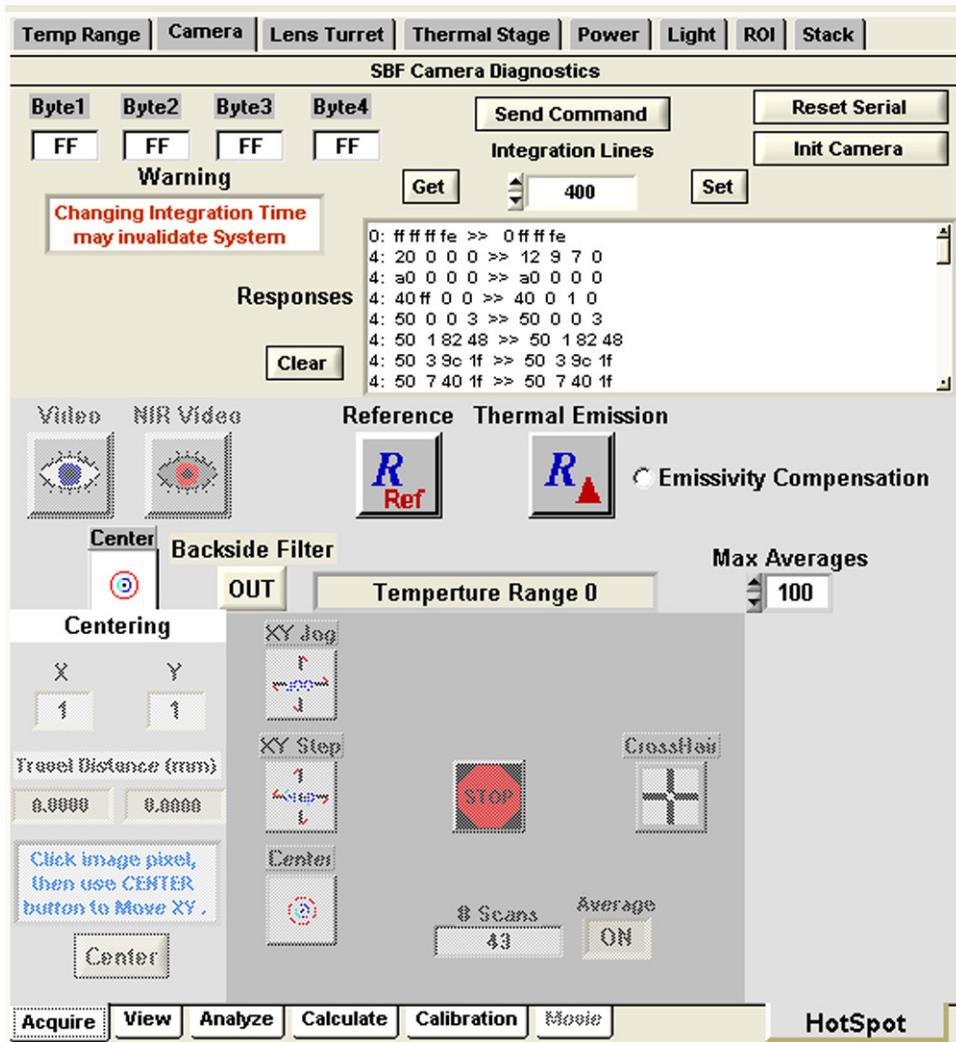


Temp Range Tab (top) shown with the Calibration Tab (below)

5.4.7.1 Overview

The integration time of the infrared detector has been preset at the factory to give the best signal to noise ratio for Hot Spot detection. In some cases, for example if the die is quite hot, the camera may saturate. The user may adjust the "Temperature Range" by checking the Range 1 option to increase the InfraScope dynamic range in order to see higher temperatures.

5.4.8 Camera Tab



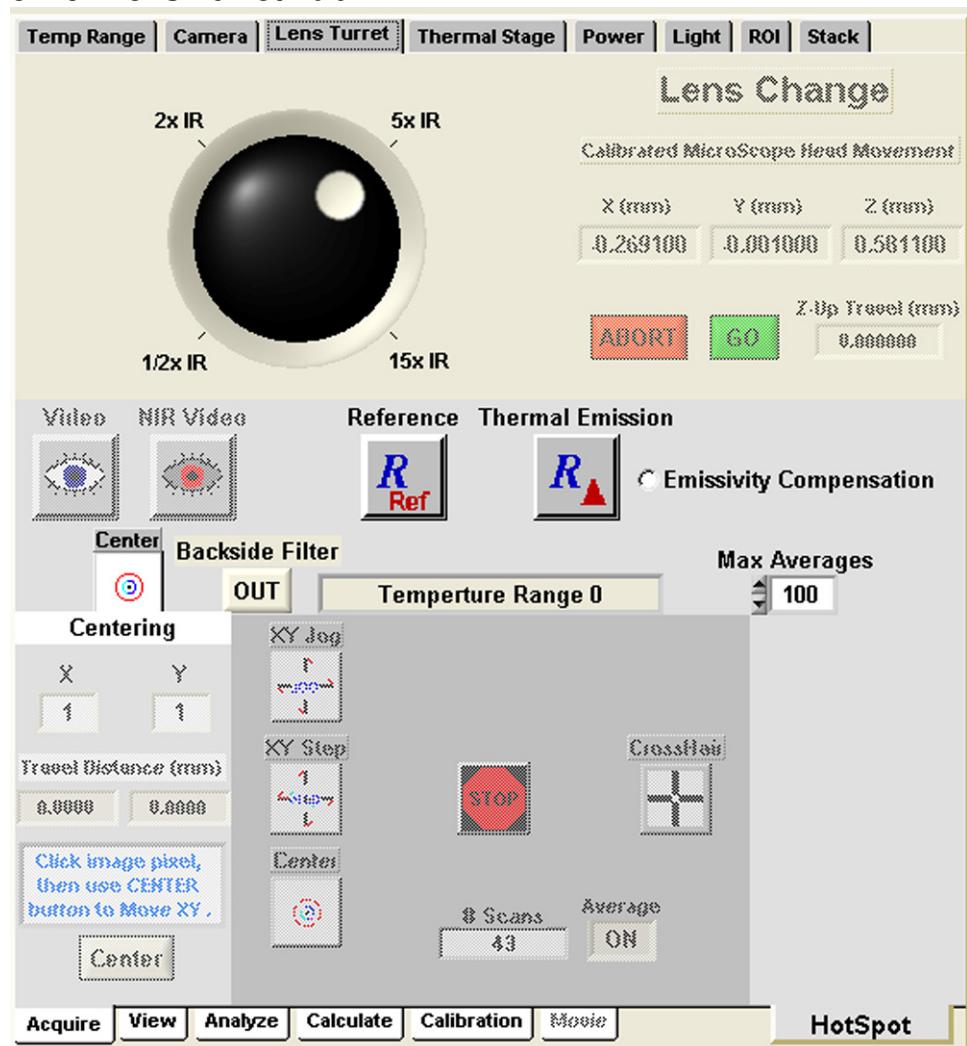
Camera Tab (above) seen with Acquire Tab (below)

5.4.8.1 Overview

The camera tab is used by factory personnel for infrared detector diagnostics.



5.4.9 Lens Turret Tab



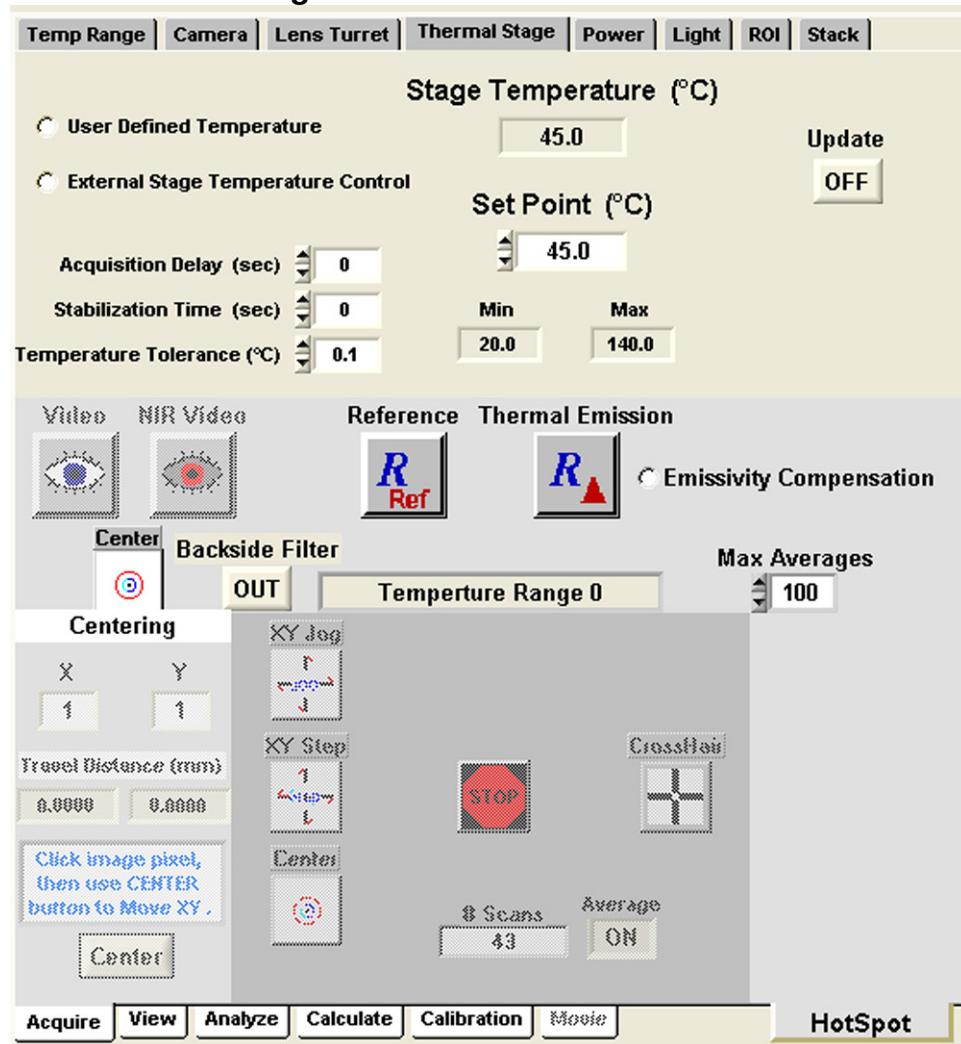
Lens Turret Tab (top) seen with Acquire Tab (bottom)

5.4.9.1 Overview

The Lens Turret Tab is used for changing microscope objectives. Select a lens with the ball or by clicking on the lens description text and click go. The software will first raise the optical head by the distance specified in the Z-Up travel box, or by the default amount in the Headmaster System.ini file. This 'up' motion is optional. It is intended to give the lenses room to clear micro-probes, wires or other setup obstructions. Whenever it isn't required for clearance the user should set the Z-Up value to 0 to save time during lens changes. After rising, the lens turret will move to the appropriate position, the intermediate optics stage will move if appropriate for the selected lens, and the optical head will then descend again. Finally, the computer will adjust the X, Y and Z position of the head to precisely adjust the parfocality and par-centering of the lens to the last used lens.

If the user has a multi-sensor system the Lens Tab may show both NIR (near infrared) and IR (infrared) lenses. If an NIR lens is selected then the R_{ref} and R_Δ buttons will be greyed out. The R_{ref} and R_Δ buttons only work with IR lenses.

5.4.10 Thermal Stage Tab



Thermal Stage Tab (top) seen with Acquire Tab (bottom)

5.4.10.1 Overview

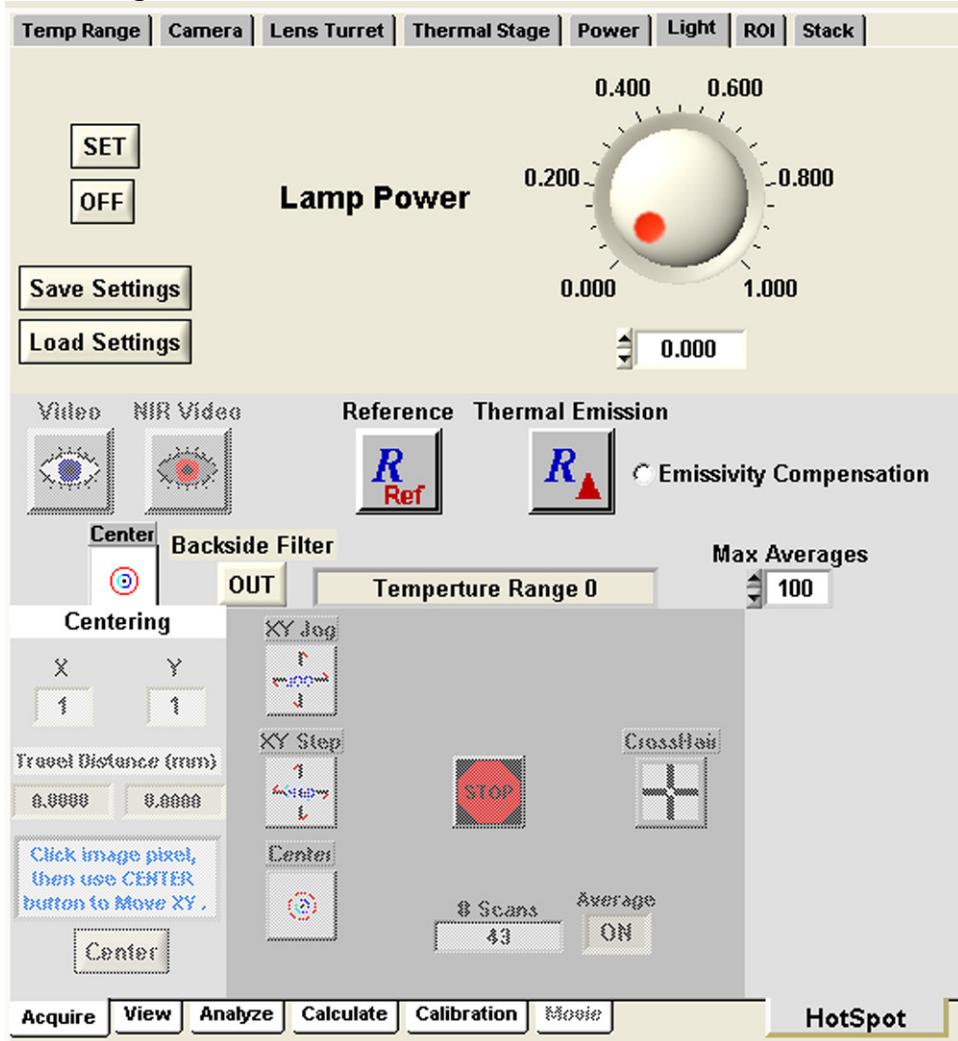
The Thermal Stage Tab provides temperature controls for the QFI thermal stage which is fielded as a very useful option with the QFI InfraScope. If equipped, this tab will let the InfraScope user set the stage temperature to warm or in some cases to cool the user's sample.

5.4.11 Power Tab

As an option the user may purchase specific power supplies from QFI that may be controlled from the InfraScope software via this tab.

		37 of 70	www.quantumfocus.com Quantum Focus Instruments Corp, Vista, CA USA
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5.4.12 Light Tab

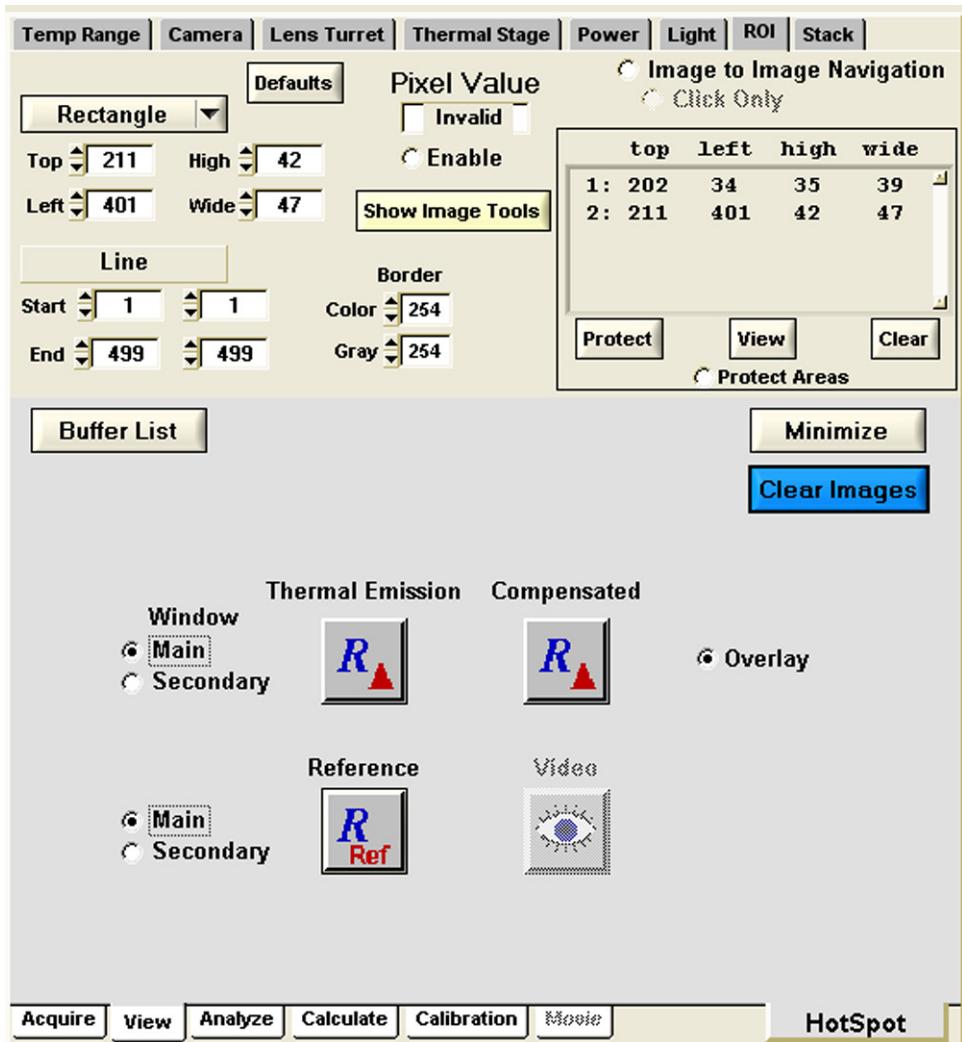


Light Tab (top) seen with Acquire Tab (bottom)

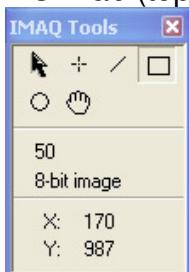
5.4.12.1 Overview

The light tab is used to adjust the illumination for the navigation camera, and also for the emmi camera on multi-sensor systems. The lamp illumination is not used with the InfraScope infrared detector. The user may adjust the illumination with the virtual knob or by typing in a value. The user may set or recall particularly useful starting values.

5.4.13 ROI Tab



ROI Tab (top) seen with View Tab (bottom)



and the IMAQ Tools (Inset)

5.4.13.1 Overview

ROI is Region of Interest. This Tab gives the user access to the [IMAQ tools](#) which are useful for drawing boxes and lines in the image area, and which are essential to protecting areas (see [Tools Tab](#)) and useful for the analysis functions ([Analyze Tab](#)). When the user

draws a box or line, the start and stop dimensions appear in the windows in the ROI tab and may be manually changed there.

5.4.13.2 Image to Image Navigation

Checking this option causes a cursor to appear in the secondary window that is physically coincident with the mouse position in the main window, and vice-versa. This can be very useful for quickly identifying sources of hot spots.

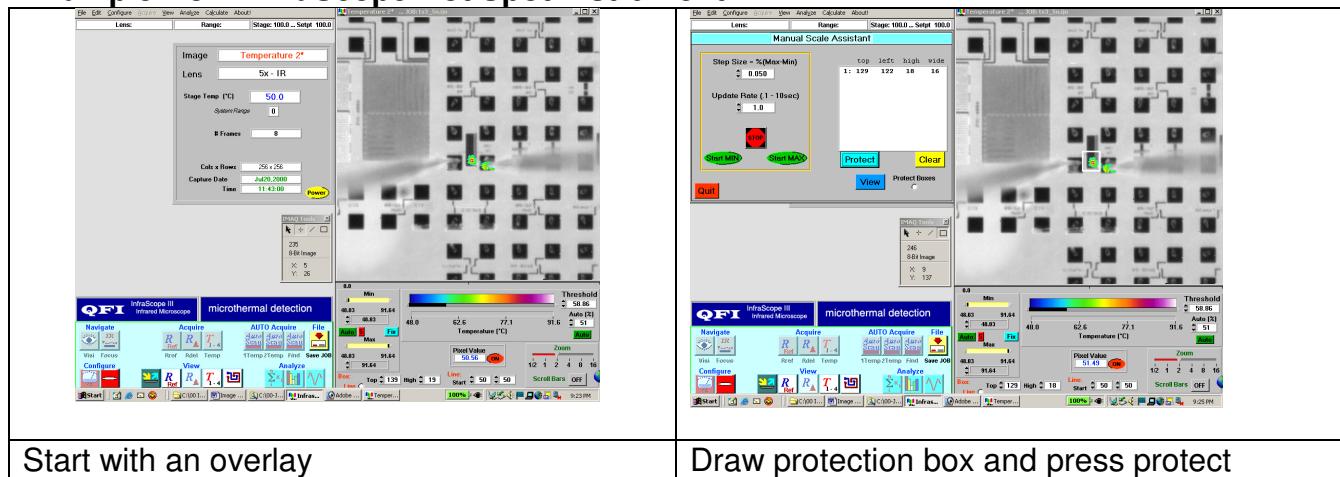
5.4.13.3 IMAQ Tools

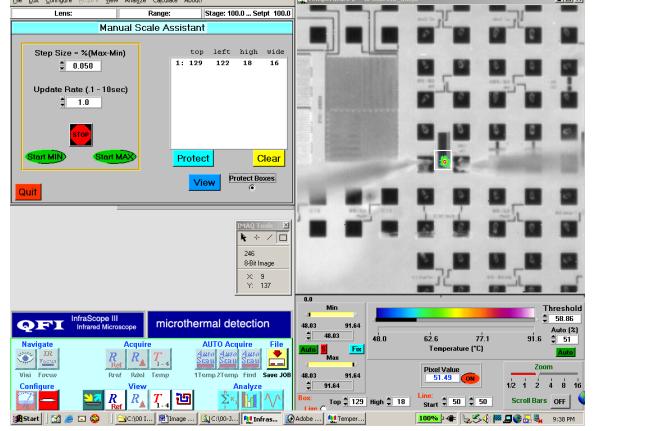
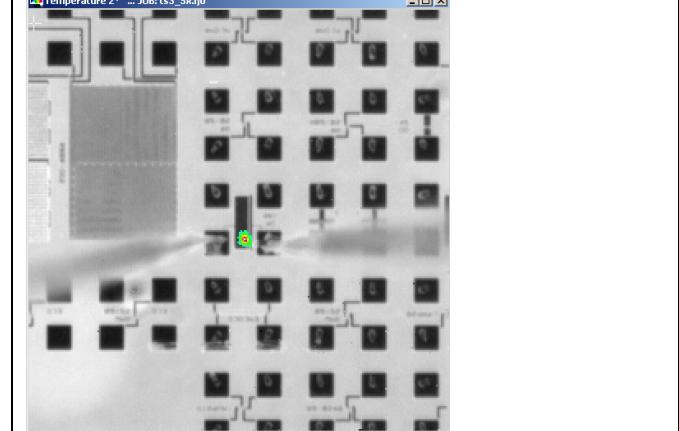
The IMAQ Tools give the X & Y coordinate of the mouse when moved over the image. The box tool and line tool lets the user draw boxes or lines on the image area for analysis and other purposes. In some cases the lines or box persist when no longer wanted. Double clicking in the image area will remove residual boxes, in effect drawing 1 pixel boxes or lines. Sometimes the persistence of the IMAQ box is an asset, such as marking a spot to observe closely in subsequent measurements or when digitally zooming.

5.4.13.4 Protect Areas

The FA engineer usually wants a nice overlay image of the discovered hot spot for their report. If the hot spot is faint or noisy, or if it is accompanied by known non-defect hot spots the user may wish to use the “**Protect**” feature. An example is shown below where the hot spot at the probe tip isn’t meaningful. The example uses the Protect feature to remove the irrelevant spot at the probe. The image can be improved and simplified for presentation purposes with the Protect feature. The user can draw a box around the real current leak (using the [IMAQ tools](#)). Then the user presses the “Protect” button to record the protected area in the Assistant. The user may draw and record multiple boxes for more than one area. When finished, press “View” in the Assistant to erase any remaining color overlay outside the protected areas.

Example from InfraScope Hot Spot instrument



	
<p>Press View to remove unprotected overlay</p>	<p>Uncheck the “Protect Boxes” to remove box from image. It may be needed to remove IMAQ tool residual box by drawing a minuscule line or box with the IMAQ tools.</p>

5.4.14 Stack Tab

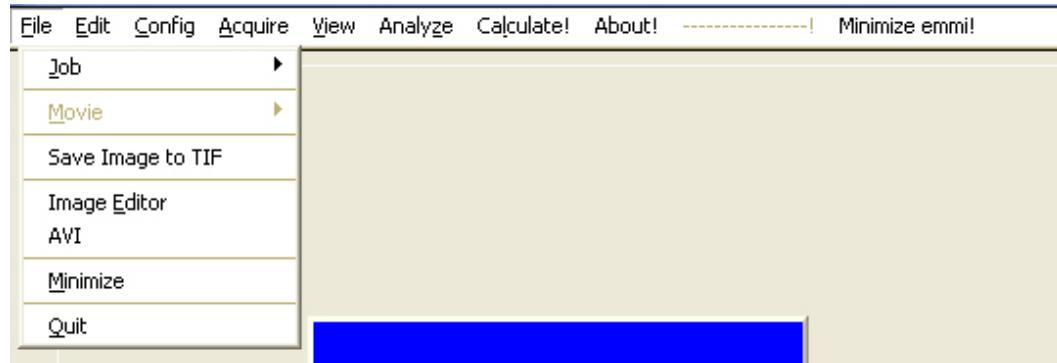
The stack tab is in development and not yet fully implemented but when implemented will permit the user to readily review previously acquired images.

5.5 Pull Down Menus

5.5.1 Overview

The InfraScope software includes traditional pull down menus from the top part of the graphical user interface. Some of these items are duplicated and more easily accessed from the tabbed menu area. However there are some actions, particularly calibration or file opening and saving that can only be accessed from the pull down menus.

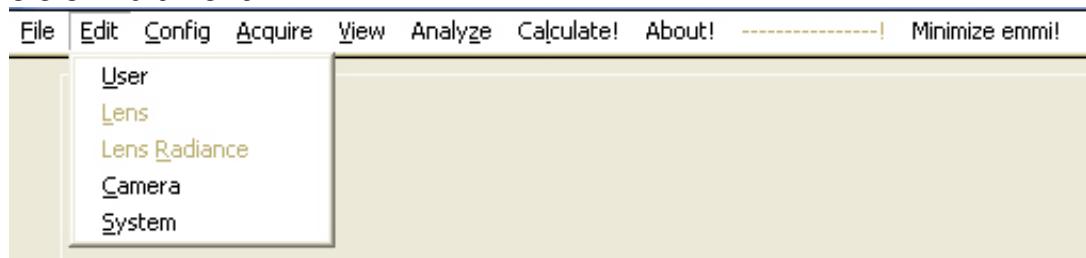
5.5.2 File Menu



The file menu is used to save and open jobs in the full bit depth of the InfraScope detector. Saving data through the job menu is the best way to preserve all the data for post processing.

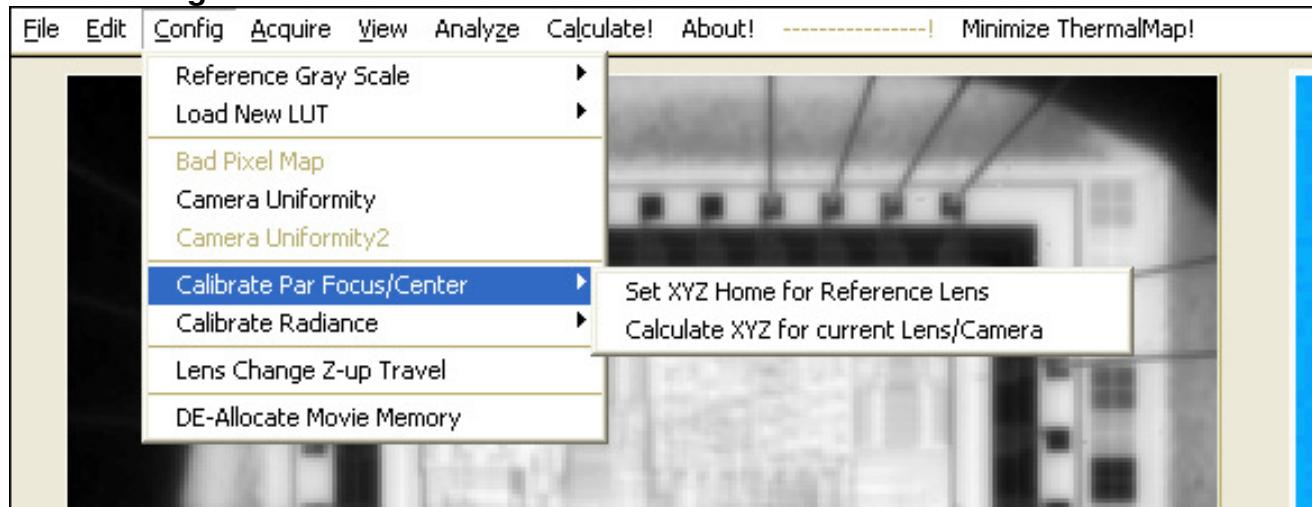
Live screen images may also be saved to TIF formats from the file menu, very convenient for inserting images into reports but all ancillary information about the image is lost. The Image Editor and AVI commands call up 3rd party programs that launch an image editor or screen movie capture utility. The very excellent Paint Shop Pro ships with the instrument, but if the user prefers a different program such as Adobe PhotoShop, she may change the pointer in [user.def](#) to launch the appropriate program.

5.5.3 Edit Menu

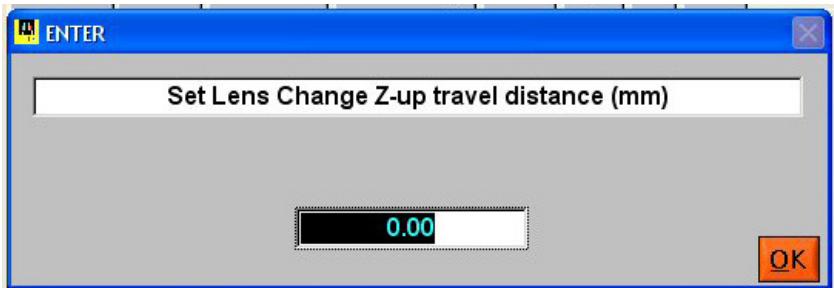


Some user preferences are stored in a file called [user.def](#), located in ...Program Files/QFI/InfraScope/Parms. An example is the name and location of the user's preferred image editor program. The easiest way to edit the user.def file is from the Edit menu. Factory personnel can also edit the camera.def and System.def files from this menu.

5.5.4 Config Menu

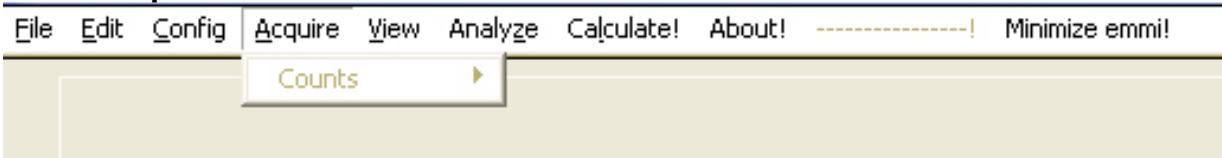


The config menu gives access to the calibration routines. The calibration functions will be discussed in the [maintenance and calibration](#) section.



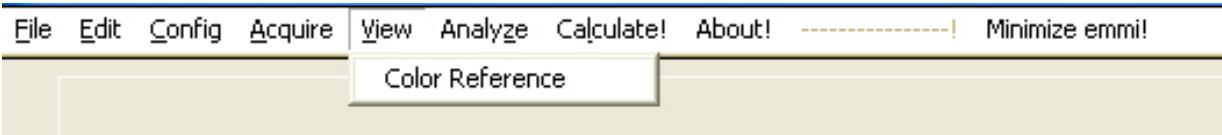
The **Z-up Travel** function causes the microscope head to lift before rotating the lens turret, in order to clear microprobes or other obstructions. The default value is set in the Headmaster software but the user can set a new value for a particular InfraScope session (from launching the InfraScope software to closing it) from this menu.

5.5.5 Acquire Menu



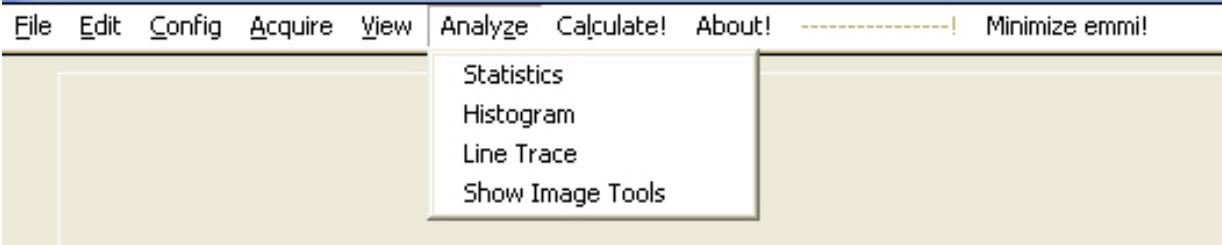
The **Acquire Menu Counts** function acquires an image comprised of raw A/D counts from the InfraScope detector. This image may be used for mapping bad pixels (see [calibration](#)).

5.5.6 View Menu



View Color Reference permits viewing a false color version of the reference image.

5.5.7 Analyze Menu



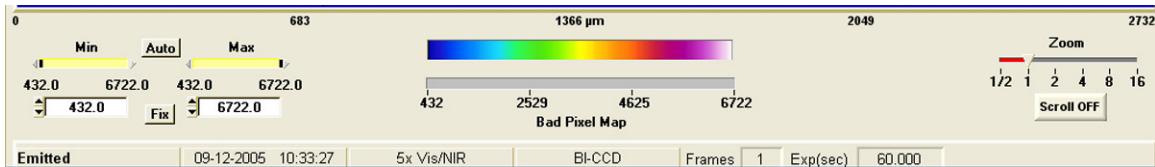
These functions are available from the tabbed menus.

5.5.8 Minimize InfraScope!

IMPORTANT: Some irritating limitations in the InfraScope software development system (Lab Windows) force us to minimize the InfraScope window from this command. Otherwise the user will discover that various Lab Windows daughter windows will not minimize

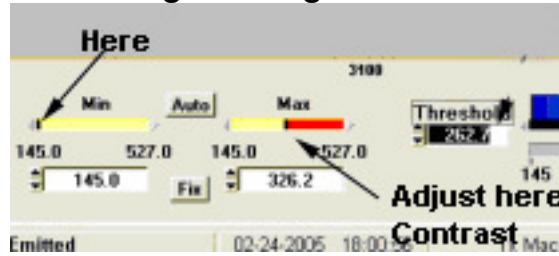
properly. QFI joins our users in waiting for a version of National Instruments Lab Windows that follows the MS Windows protocol more closely.

5.6 Image Information & Adjustment Regions



This part of the user screen provides information about the image, and permits the user to scale and zoom the image.

5.6.1 Image Scaling



The sensitive InfraScope detectors have much more dynamic range, 14 or 16 bits, than can be displayed on the screen. The software uses two kinds of scaling to fit the useful data into the dynamic range of the display, normal scaling and sigma scaling if it is enabled. Switch between the two types of scaling by pressing the auto button. In either case the user can manually scale the image by sliding the scaling sliders shown above or by inserting different scaling numbers in the boxes below the sliders. One reason to change the default scaling might be accidental detection of cosmic rays. When a cosmic ray passes through a pixel, it instantly saturates it, but it rarely affects the nearby pixels. So with normal scaling the min might be the A/D threshold but the max will be pegged to the cosmic ray event. If you have a barely detectable hot spot on that capture you probably won't even see it with such wide scaling. So if you see the max pegged at 10's of thousands of counts, try manually reducing the max scaling to uncover hot spot details at much lower counts. The idea behind the auto sigma scaling is just that, to disregard pixels that are more than some number of standard deviations away from the mean when computing the image scaling.

5.6.1.1 Auto and Fix buttons

The image will automatically scale to auto sigma scaling if enabled, or to normal auto scaling if not. On captured images pressing the **Auto** button switches between sigma and normal scaling. On live images pressing the **Fix** button stops autoscaling at the immediately current scale settings. Likewise adjusting the sliders on a live image will also stop the autoscaling.

5.6.1.2 Normal Scaling

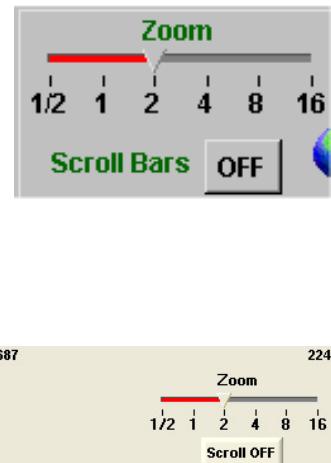
In normal scaling the displayed image is scaled to the brightest and darkest pixels. If it is a false color image this range is distributed evenly amongst 256 colors. In this mode detected cosmic rays can suppress desired hot spots. Pressing Auto toggles between normal scaling and sigma scaling.

5.6.1.3 Sigma Scaling

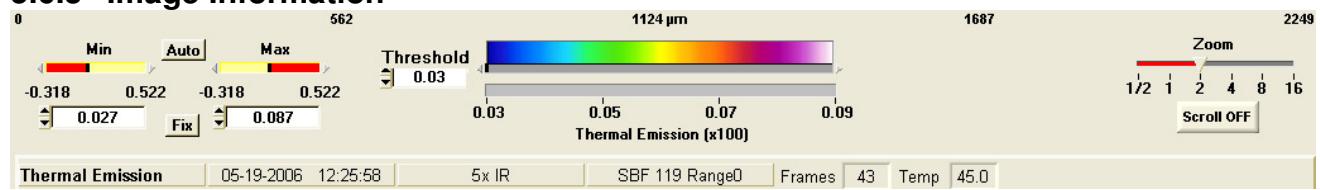
Sigma scaling is enabled or disabled and configured in the system.ini file in the InfraScope parms directory. In Sigma scaling the displayed image is scaled to fit between a fixed number of standard deviations above and below the mean pixel value of all of the pixels. That is, pixels with values above and below the selected cut-off values will be disregarded when computing the image scaling. Generally the lower limit should be about 2 or 3 sigma below the mean, and the upper cut-off should be 6 or 8 or more sigma above the mean. Pressing Auto toggles between normal scaling and sigma scaling.

5.6.2 Zoom & Scroll

The image display can be **Zoomed** and **Scrolled** using the controls shown at right. 1X zoom displays 1 infrared detector pixel per computer display pixel. The default zoom may be set in the user.def file. At manufacture, it is selected based on the detector array size and monitor size to just fill the image window. Scrolling is turned ON/OFF by toggling the **Scroll Bars** button. When ON, normal windows style slider bars will appear on the image.



5.6.3 Image Information

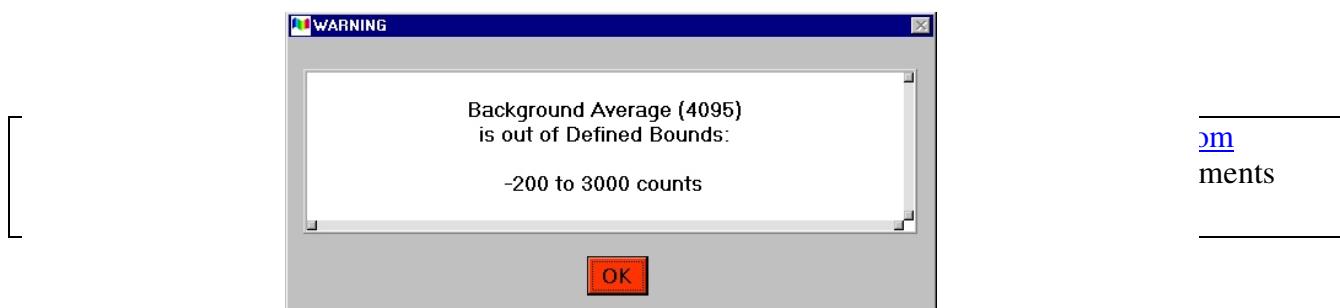


At the bottom of the image information area is a bar with details about the displayed image. In the case of the above example, the image is a thermal image taken on 5-19-2006 with a 5x IR lens, SBF camera set to range 0. The final image was comprised of 43 averaged frames. The thermal stage was set to 45 Celsius.

5.7 Image Acquisition Messages and Dialogs

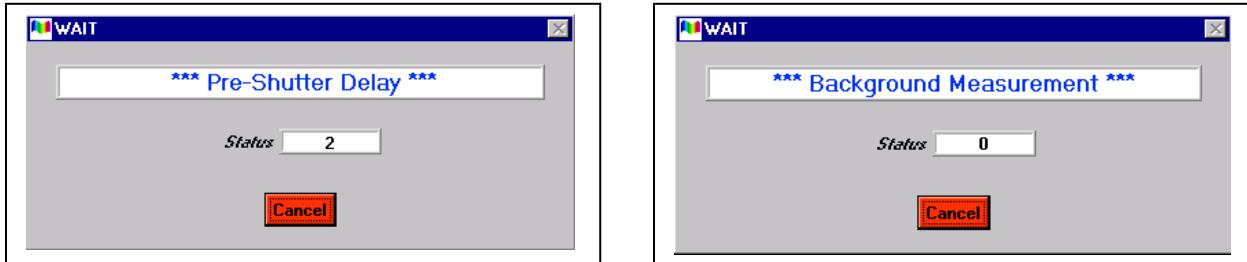
5.7.1 Background Out of Bounds

The Background out of Bounds message indicates a problem with the background image. Usually this means the User should refresh the supply of LN2 in the dewar (or wait for the detector to finish cooling).



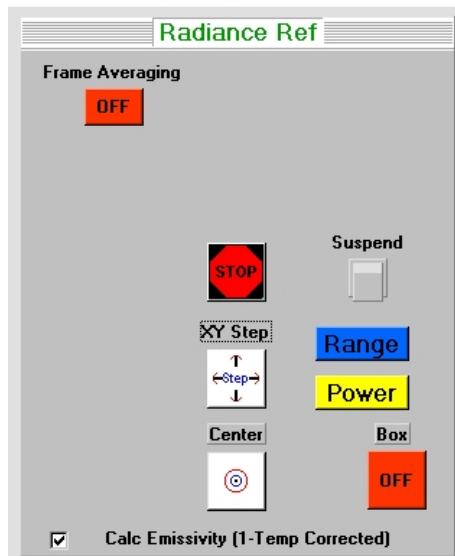
5.7.2 Pre-Acquire

Depending on configuration, the InfraScope may acquire a background image with a shutter before displaying the live radiance or temperature image. This is always true on the InfraScope I and II. The following two **WAIT** panels will normally appear in sequence. The Pre-Shutter wait is a time delay set by a system parameter (nominally 2 sec). This is the delay after the shutter is closed and the system starts to acquire the background measurement. The second wait panel is for the background acquisition. Another wait panel may occur (such as during AutoScans) which is a Post-Shutter delay. This may be necessary if frame averaging is going to start immediately.



5.7.3 Acquire

The Acquire control panel pops up during most acquisitions and allows the user to adjust the acquisition.



Example Acquire Dialog Box

5.7.3.1 Stop Button

The **Stop** button terminates and stores the acquisition in a memory buffer.



5.7.3.2 Frame Averaging

The **Frame Averaging** is cumulative frame averaging that continues to average when on, and reverts to live when off. To average, turn it on and then STOP the acquisition with averaging still “on” after

		46 of 70	www.quantumfocus.com Quantum Focus Instruments Corp, Vista, CA USA
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the desired number of frames. The frame count will be displayed. Averaging can be stopped and restarted at will.

5.7.3.3 Suspend

The **Suspend** button freezes the acquisition. This may be necessary to enter new Min/Max values into the manual range fields, as the system is continually busy with the live updating unless suspended.

5.7.3.4 Range

The **Range** button allows the user to increase the dynamic range of the detector if a hot portion of the sample is saturating. It trades sensitivity for higher temperature ranges. Generally the range should be left at range 0 unless there is saturation, evidenced by grey pixels. The unpowered Rref should always be taken in range 0. See the expanded description for “**Set Temperature Range**” in the **Configure** menu.

5.7.3.5 Center

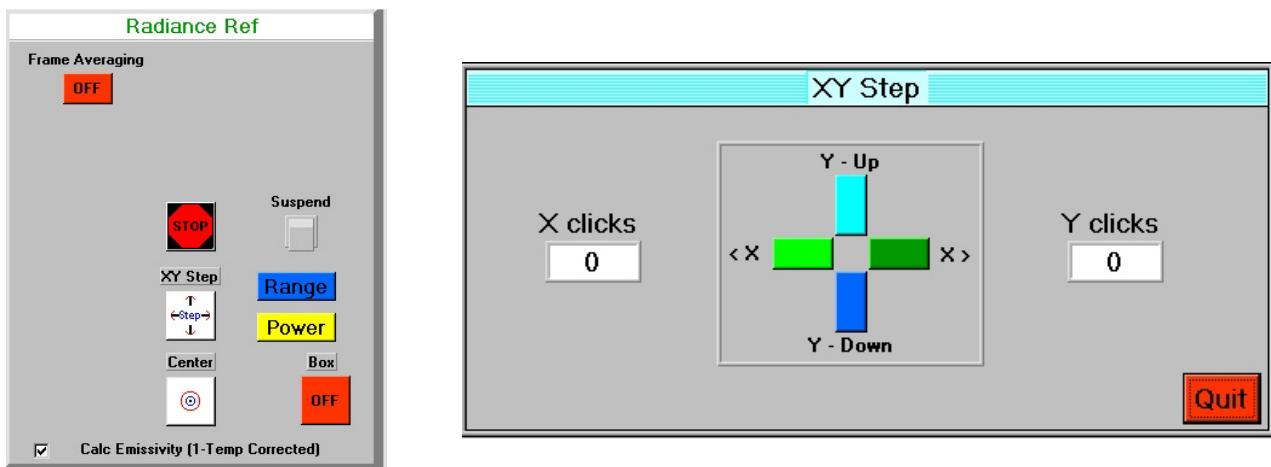
The **Center** function lets the user center the InfraScope over an arbitrary feature with a mouse click. For an expanded description see “**XY Center**” in the **Configure** menu.

5.7.3.6 Power

The **Power** button lets the user control optional programmable power supplies. For an expanded description see “**DUT Power**” in the **Configure** menu.

5.7.3.7 XY Step

The **XY Step** function lets the user step in fixed increments about the sample. It is particularly useful when the sample is very large and the user needs to step over several fields of view to see the entire sample. For example the user could start in the upper left corner of the sample, and following that measurement, use the **XY Step** function to move an entire FOV (field of view) to the right for the next measurement, then down, then left and so forth until the sample is completely measured. The **X clicks** and **Y clicks** fields tell the operator how many steps in that direction he has taken.



5.7.3.8 Box Button

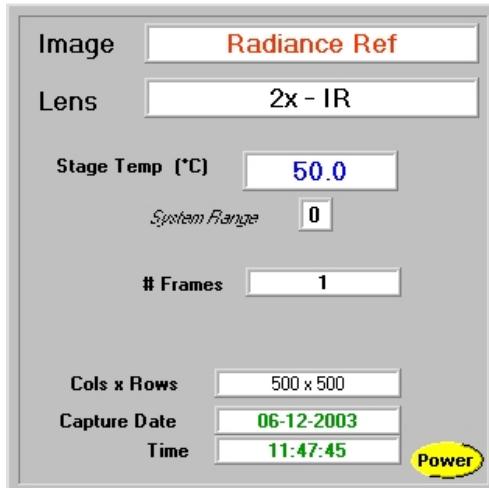
The **Box** button causes the drawn or default box to appear in live images. The user can also **Zoom** a live image using the slider bar at the lower right of the image display area. The normal default setting depends on the number of pixels in the IR detector.



5.7.4 Image Display

Info Box

Whenever an image is displayed, an Information Box, shown below, is displayed on the left of the Main Screen. This box identifies the main parameters concerning how and when this image was acquired.



6 Maintenance & Calibration

6.1 Recommended Service Intervals

We recommend that the InfraScope get a checkup annually from a factory service engineer. Most calibrations do not change significantly in less than a year but gradual changes that often are imperceptible to the user do occur and these may be quickly detected and corrected by a QFI service engineer.

6.2 Back up the Software !!!!

Computer viruses or errant users can render your instrument quite useless. We recommend that the instrument owner back up the instrument software periodically, and especially before any calibration. The QFI software is located in the C:\Program Files\QFI\... QFI typically ships the instrument with a 2nd hard drive cloned from the first. This 2nd drive can be used to restore the instrument to an “as built” condition but it will not have any calibrations or configuration data added at the customer’s site. Therefore we recommend periodically copying the contents of the QFI subdirectory to CD or safe server.

6.3 Periodic Calibration

6.3.1 Parfocus / Parcenter Calibration

The Parfocus/Parcenter Calibration sets the X, Y, and Z displacement required for automated par-focus and par-center movements for lens changes and also for changes between sensors, e.g. from the navigation camera to the hot spot camera. When properly adjusted, an image that is focused and centered for one lens will be fairly centered and focused after switching to the next lens or when switching to a different sensor. Some additional slight focusing and centering will may be required, but the object should not be lost from the field of view. The software includes a calibration value for every lens for every sensor. This is potentially very many calibrations, so in order to make a partial calibration tractable, one lens for each system is designated the Reference lens, so that its cal values are a partial calibration tractable, one lens for each system is designated the Reference lens, so that its calibration values are arbitrarily set to X=Y=Z=0.

6.3.1.1 Required Calibration Interval

Calibrate only as needed, usually only if a lens or head has been removed or replaced.

6.3.1.2 System Reference Lens

In the software a “lens” is defined as a particular objective combined with a particular sensor. The software includes a parfocus/parcenter calibration value for each of these defined lenses. If your system includes many sensors then there may be very many defined lenses, e.g., 5 sensors times 7 lenses for 35 defined lenses. In order to make a partial calibration tractable, one lens in each shipped system is designated the Reference lens, so

		49 of 70	www.quantumfocus.com Quantum Focus Instruments Corp, Vista, CA USA
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that its calibration values are arbitrarily set to X=Y=Z=0. Each par-centering calibration is performed with respect to this reference lens, and begins with homing this lens. In most cases the factory sets the System Reference Lens to be the 5xNIR in the video camera mode. If your system is not equipped with a 5xNIR, it may be the 2.5xNIR or some other low magnification lens.

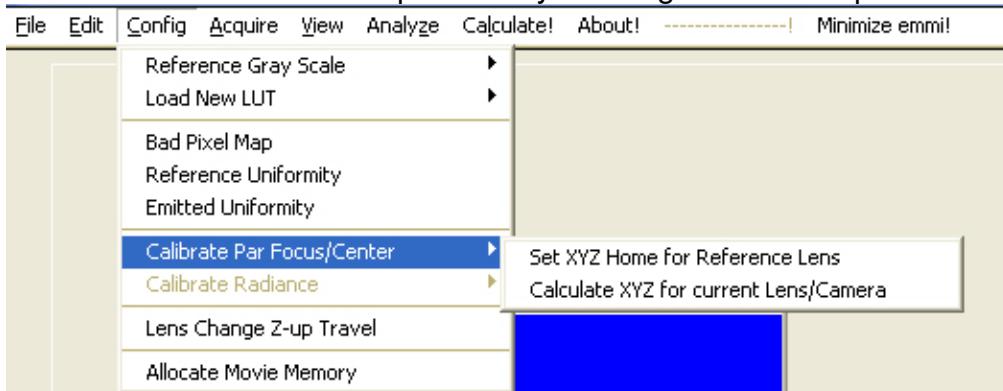
6.3.1.3 Determining the System Reference lens

6.3.1.3.1 EASIEST METHOD TO FIND REFERENCE LENS

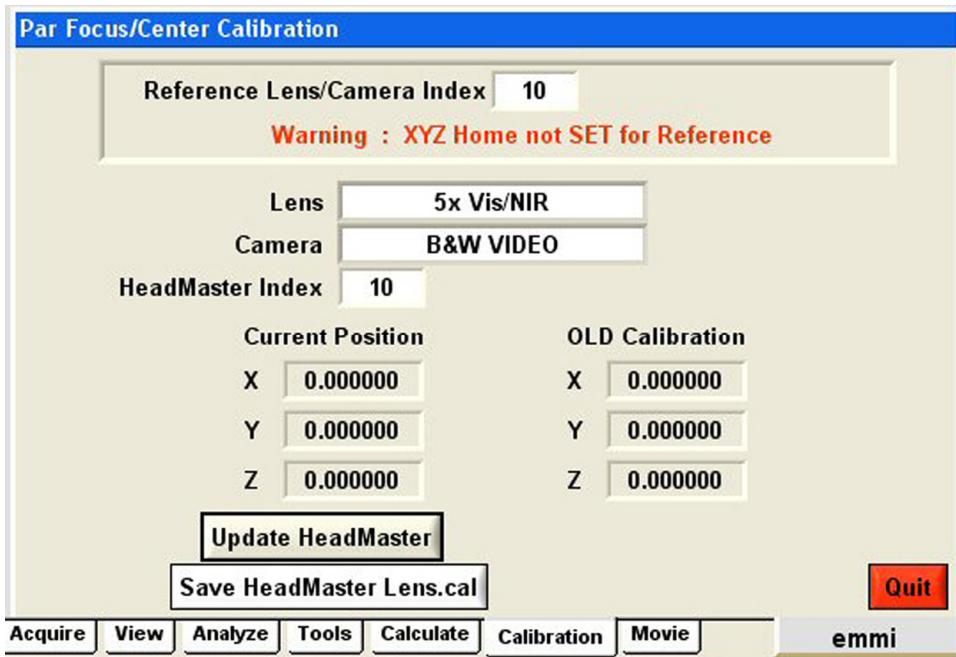
Close all applications and turn off the computer. Restart the computer and restart InfraScope. The default starting position will be the Reference Lens.

6.3.1.4 Procedure

- 1) Choose a suitable target with a feature that can be resolved with the highest and lowest magnification lens. A discarded wafer fragment or decapped sample will do, and generally a fine feature very close to the corner of the die is best. The corner is easy to see with the macro, and the fine feature works well for the high magnification lens.
- 2) Focus and center the System Reference Lens on the user-selected fiducial (see the section on [Determining the System Reference Lens](#)).
- 3) Using the [Config](#) pull down menu, choose “Set XYZ Home for Reference Lens”. This starts the calibration process by creating a reference position.



- 4) Again using the Config pull down menu, choose Calculate XYZ for current Lens/Camera. Open the [Calibrate Tab](#) to see the resulting menu.



- 5) Use the Acquire Tab to acquire an image from the desired sensor, e.g., from the Deep Depletion camera.
- 6) It is best to work up to the highest magnification lens and perform the calibration when descending back to the macro. So in this step, migrate up to the high magnification lens, then focus and center on the fiducial. When you have the highest magnification for the desired sensor centered and focused, capture the image (press stop).
- 7) Press "Update HeadMaster" to register the new XYZ location of this lens.
- 8) Switch to the next lens and repeat until finished with all of the lenses suitable to that sensor.
- 9) When finished, press "Save HeadMaster Lens.cal". That will write the calibration to the System Lens.cal file.

6.3.2 Radiance Calibration

The radiance calibration is the fundamental calibration for the InfraScope. It creates the relationship between the A/D output of the infrared detector, and the infrared radiance from a blackbody target vs. temperature. All InfraScope computations require a sound radiance calibration.

6.3.2.1 Required Calibration Interval

Perform the radiance calibration once per year, or if there are physical changes to the lenses or physical location of the InfraScope. A radiance calibration is required for each lens and each range.

6.3.2.2 Radiance Calibration Target

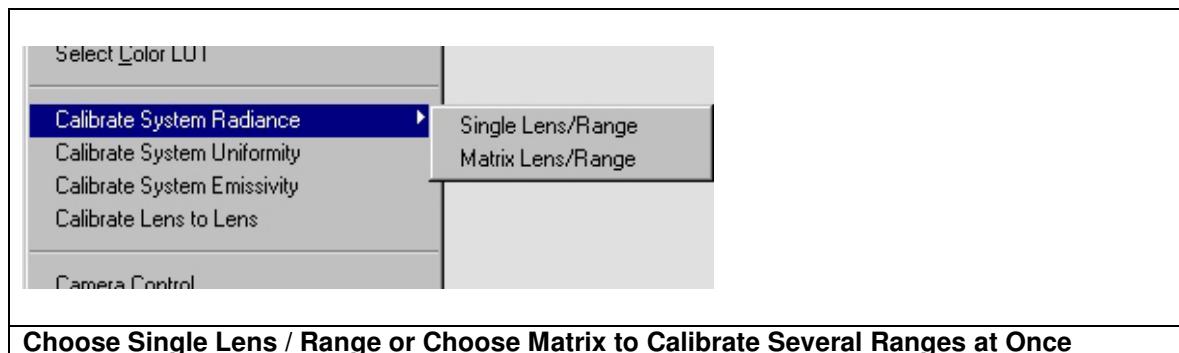
The InfraScope is shipped with a special radiance calibration target. It is a 2 inch square flat target with 4 target holes of varying size in each quadrant. The top is scored to assist navigating to the target holes. The interior of the target is physically and chemically prepared to be extremely black in the infrared.



Uniformity (left) and Radiance (right) Calibration targets

6.3.2.3 Radiance Calibration Sequence

- 1) Before starting, it's a good idea to back up the directory where the existing radiance calibrations are stored. Generally that location is C:\Program files\QFI\Thermal Map\Parms. Copy the directory and name the copy C:\Program Files\QFI\Thermal Map\(today's date)Parms, (e.g. C:\Program Files\QFI\Thermal Map\10-16-08Parms).
- 2) Place the Radiance Calibration target on the thermal stage. Use a thin layer of thermal grease to ensure that the thermal contact is excellent.
- 3) Using IR focus and the low magnification lens, **navigate**, and **center** to the large calibration hole. Focus on the lid at the edge of the hole. Use the large hole for all lenses and all ranges, in fact, for all Radiance Calibrations. **Focus** on the lid at the edge of the hole. That will make the blackbody surface slightly out of focus.
- 4) Capture a Radiance Reference image of the target. Using the IMAQ tools, inscribe a square box well within the outlines of the circular target. This box is the area that will be used for the radiance calibration.
- 5) Using the Configure menu, choose Calibrate System Radiance and then either Single Lens / Range or Matrix Lens / Range. Use the Single Lens option for quickly calibrating just one lens and range for a particular measurement. The Single Lens / Range will calibrate the currently selected lens and range. (The currently selected Lens and Range appear in a thin white window on the top left of the InfraScope display). The matrix is more convenient for a maintenance level system calibration. The matrix method will calibrate all of the checked ranges for a given lens, using the defaults in the cal files and automatically save the data.



<p>Counts to Radiance Calibration</p> <p>Start Temperature (°C) <input type="text" value="45.0"/></p> <p>Step (°C) <input type="text" value="15.0"/></p> <p># of Temperatures <input type="text" value="4"/></p> <p>Target Emissivity <input type="text" value="1.000"/></p> <p>Range <input type="text" value="0"/></p> <p>Lens Index <input type="text" value="1"/></p> <p>Lens <input type="text" value="1x - IR"/></p> <p>Step <input type="text" value="0"/></p> <p>Temperature (°C) 45.0</p>  <p>Start Quit</p>	<p>Calibration Matrix</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th>Low</th> <th>Normal</th> <th>High</th> <th>Extended</th> </tr> </thead> <tbody> <tr> <td>Lens 1</td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> </tr> <tr> <td>Lens 2</td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> </tr> <tr> <td>Lens 3</td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> </tr> <tr> <td>Lens 4</td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> </tr> <tr> <td>Lens 5</td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> </tr> <tr> <td>Lens 6</td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> </tr> <tr> <td>Lens 7</td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> </tr> <tr> <td>Lens 8</td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> </tr> </tbody> </table> <p>Start Calibration Sequence Cancel</p>		Low	Normal	High	Extended	Lens 1	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Lens 2	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Lens 3	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Lens 4	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Lens 5	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Lens 6	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Lens 7	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Lens 8	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
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Radiance Cal – Single Lens / Range	Radiance Cal - Matrix																																													

- 6) The factory installed cal files have default values for the start and stop temperatures and the number of steps. Generally these are the most appropriate and should not be changed without consulting the factory.
- 7) Press start and let the calibration proceed. On the Single Lens / Range option the new values will appear in the window. If you wish you may compare them with the corresponding file in the previously saved parms directory.
- 8) When prompted, save the data and exit the Cal routine.
- 9) To cal a different lens or range, select it from the Configure Menu. Allow the suggested par focusing and par centering. Re-enter the Cal System Radiance routine from the Configure menu and press the start button.

6.3.2.4 RADIANCE CALIBRATION MATRIX

A Radiance Calibration is required for each lens and each range. On an InfraScope 3 used both for hot spot detection and thermal mapping, it is required for both no-shutter and normal shutter conditions, each with each lens and each range. The total number of conditions to calibrate is intimidating but outside of the annual maintenance interval the user need only calibrate the particular lens/range combination as needed.

InfraScope I and II Radiance Cal Matrix			If Option Installed
1x Range 0	1x Range 1	1x Range 2	1x Range 3
5x Range 0	5x Range 1	5x Range 2	5x Range 3
15x Range 0	15x Range 1	15x Range 2	15x Range 3
Additional IR lenses if installed			

InfraScope 3 Radiance Cal Matrix			If Option Installed
2x Range 0 no-shut.	2x Range 1 no-shut	2x Range 2 no-shut	1x Range 3 no-shut

5x Range 0 no-shut	5x Range 1 no-shut	5x Range 2 no-shut	5x Range 3 no-shut
15x Range 0 no-shut	15x Range 1 no-shut	15x Range 2 no-shut	15x Range 3 no-shut
Additional IR lenses if installed			
Include If Thermal Mapping Option is Installed			If Option Installed
2x Rnge 0 w/shut.	2x Range 1 w/shut	2x Range 2 w/shut	1x Range 3 w/shut
5x Range 0 w/shut	5x Range 1 w/shut	5x Range 2 w/shut	5x Range 3 w/shut
15x Range 0 w/shut	15x Range 1 w/shut	15x Range 2 w/shut	15x Range 3 w/shut
Additional IR lenses if installed			

6.3.3 Uniformity Calibration

All infrared detectors are characterized by some degree of pixel-to-pixel gain and non-uniformity differences. This is especially true for the newest and most exotic technologies. We have incorporated algorithms in the InfraScope to correct the array uniformity on the fly. This results in a much more even image that provides a tremendous advantage when trying to isolate subtle hot spots on an IC.

6.3.3.1 Required Calibration Interval

Perform the uniformity calibration as needed or at least once per year. Uniformity Calibration may be required if there are physical changes to the lenses or physical location of the InfraScope. Uniformity calibration will not appreciably affect the accuracy of thermal mapping, but it is very important to hot spot detection and it is important to the look and feel of the InfraScope images.

6.3.3.2 Uniformity Calibration Matrix

A uniformity calibration is required for each lens and each range. On an InfraScope 3 used both for hot spot detection and thermal mapping, it is required for both no-shutter and normal shutter conditions, each with each lens and each range. The total number of conditions to calibrate is intimidating but outside of the annual maintenance interval the user need only calibrate the particular lens/range combination that shows need.

InfraScope I and II Uniformity Cal Matrix			If Installed
1x Range 0	1x Range 1	1x Range 2	1x Range 3
5x Range 0	5x Range 1	5x Range 2	5x Range 3
15x Range 0	15x Range 1	15x Range 2	15x Range 3
Additional IR lenses if installed			

InfraScope 3 Uniformity Cal Matrix			If Installed
2x Rnge 0 no-shut.	2x Range 1 no-shut	2x Range 2 no-shut	1x Range 3 no-shut
5x Range 0 no-shut	5x Range 1 no-shut	5x Range 2 no-shut	5x Range 3 no-shut
15x Range 0 no-shut	15x Range 1 no-shut	15x Range 2 no-shut	15x Range 3 no-shut
Additional IR lenses if installed			
Include If Thermal Mapping Option is Installed			If Installed
2x Rnge 0 w/shut.	2x Range 1 w/shut	2x Range 2 w/shut	1x Range 3 w/shut
5x Range 0 w/shut	5x Range 1 w/shut	5x Range 2 w/shut	5x Range 3 w/shut
15x Range 0 w/shut	15x Range 1 w/shut	15x Range 2 w/shut	15x Range 3 w/shut

		54 of 70	www.quantumfocus.com Quantum Focus Instruments Corp, Vista, CA USA
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6.3.3.3 Uniformity Calibration Target

The InfraScope is shipped with a **Uniformity Calibration** target. It is a 2 inch square flat target containing a circular blackbody target. The blackbody target is physically and chemically prepared to be extremely black in the infrared. The black area should not be touched or mechanically cleaned, although it may be dusted with gentle clean air. The Radiance Calibration target is made from the **Uniformity Calibration** target by adding a shiny metal cover with 4 holes. In some cases the InfraScope is shipped with one or both cal targets. The Radiance target may be used for Uniformity Calibration if the cover is removed.

6.3.3.4 Uniformity Calibration Step-by-Step Procedure

- 1) Before starting, it's a good idea to back up the directory where the existing radiance calibrations are stored. Generally that location is C:\Program Files\QFI\Thermal Map\Parms. Copy the directory and name the copy C:\Program Files\QFI\Thermal Map\(today's date)\Parms, (e.g. C:\Program Files\QFI\Thermal Map\10-16-02Parms).
- 2) Place the Radiance Calibration target on the thermal stage. Use a thin layer of thermal grease to ensure that the thermal contact is excellent.
- 3) Place a straightened paper clip or some contrasting object across the top of the target to serve as an object to focus on. Be careful not to scratch or mar the target.
- 4) Using the IR Focus function and the low magnification lens, focus on the clip or focusing aid somewhere near the center of the target. The blackbody surface should be just slightly out of focus. Remove the focusing aid (clip). There should be nothing in the field of view except the calibration blackbody.
- 5) If calibrating a single lens and range, switch to it from the Configure menu. Follow the prompts for par-focusing and centering. Do not subsequently refocus.
- 6) From the Configure Menu, launch the Uniformity Calibration routine. It will default to the proper factory set values for the selected lens and range (and shutter condition) for the calibration. Note the lens and range and shutter condition described on the dialog box for appropriateness. Note too that the Low and High stage temperatures are appropriate for your stage capabilities. The other details are for factory diagnostics and may be ignored.
- 7) Start the calibration. It is not necessary to attend the calibration. The time required is limited by the ramp time of the thermal stage. It usually takes less than 10 minutes.
- 8) You will see dialog boxes appear for the thermal stage transitions and for the High and Low temperature acquisitions. When the calibration is complete all dialog boxes except the Uniformity Calibration box will disappear and the statistics will be updated.
- 9) Carefully observe the number of new **Bad Pixels**. The only time it should be more than about 10 is if the initial factory calibration (or if the bad pixel map has been lost). If it is more than a handful, cancel the Uniformity Calibration without saving the results, and restart it.
- 10) Save the results when finished and quit.
- 11) To calibrate another lens and range, switch to it with the **Configure Menu** and follow the par-focusing and par-centering prompts. Resume the **Uniformity Calibration** from the **Configure Menu**.



6.3.4 Bad Pixel Mapping

All infrared detector arrays have some bad pixels. It is normal to have up to several hundred poor pixels out of 65,000 (256x256) or 250,000 (500x500) total. This procedure identifies pixels to be excluded from processing and display. The data from these pixels will be replaced with an average of nearby surrounding pixels, excluding those already removed.

6.3.4.1 Required Calibration Interval

Map bad pixels as needed. Defective pixels are carefully mapped before shipping the InfraScope. Gradually over time some more will fail due to thermal expansion and contraction of the focal plane during cool down cycles.

6.3.4.2 How to Know When Bad Pixels Needing Mapping

Some pixels fail in a saturated on state (hot), some as off (cold). Some pixels flash. The hot or cold pixels cause the display scaling to scale the image bits over too great a range, compressing the interesting data into to few colors or gray scales. This gives the image a washed out appearance. It also causes the color bar to indicate end values that are clearly too high or low for the data. Flashing pixels are particularly bad. They cause the image scaling to frequently jump over large values, making it appear that the entire display is flashing instead of just one pixel. This can be demonstrated by fixing the display scale with the Fix button. Then the display scale will remain constant but the rogue pixel will become obvious as it flashes.

6.3.4.3 Before Starting

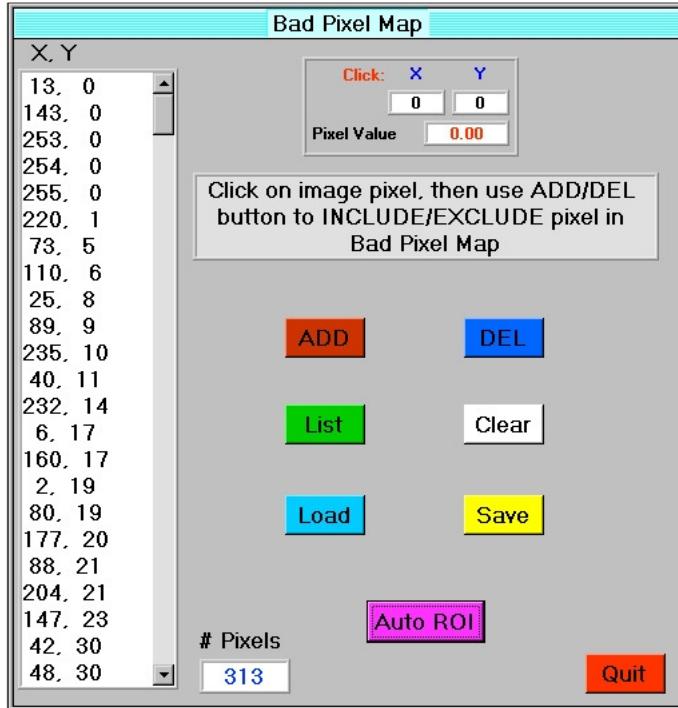
Before starting, it's a good idea to back up the directory where the existing radiance calibrations are stored. Generally that location is C:\Program Files\QFI\Thermal Map\Parms. Copy the directory and name the copy C:\Program Files\QFI\Thermal Map\{today's date}Parms, (e.g. C:\Program Files\QFI\Thermal Map\10-16-02Parms). The specific file is Badmap.def.

6.3.4.4 Procedure to Map 1 or a few bad pixels

Normally the user will want to quickly map just a few pixels quickly and then resume the measurement.

- 1) Capture and display any color image containing the bad pixel. The normally black and white Rref image can be converted to color by using the View/Color Ref menu command.
- 2) Launch the **Map Bad Pixel** routine from the **Configure Menu**. The Bad Pixel Map dialog box will appear and currently mapped bad pixels will turn gray in the image.
- 3) Click on the bad pixel.
- 4) Click on the **ADD** button. The bad pixel will turn gray. If a good pixel turned gray, click **DELETE** to remove it from the bad pixel list and try again. If you had more than 1 bad pixel click and add each.
- 5) If the pixel is hard to click with the mouse, try zooming the image to make the pixel larger and easier to click.
- 6) Save and exit the routine.

		56 of 70	www.quantumfocus.com Quantum Focus Instruments Corp, Vista, CA USA
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6.3.4.5 Mapping a hard to catch Flasher

Sometimes it's hard to catch a flashing pixel in a displayed image. This procedure details another way to do it.

- 1) From the Acquire menu, choose **Counts / Delta**. The InfraScope will acquire 100 frames in succession and then calculate and display an image of the Max – Min for each pixel. Normal pixels will have a small amount of noise so the Max – Min will be a non-zero value. Dead pixels, either full on or full off will not change value, so Max –Min will equal zero for dead pixels. Flashing pixels will exhibit a very high Max – Min. **Note: Counts Delta will locate and display all bad pixels, previously mapped and new.**
- 2) With the delta Counts image displayed, launch the **Map Bad Pixel** routine from the Configure menu. When the Bad Pixel Map routine starts, previously mapped pixels will turn gray.
- 3) The flashing pixel should have a large value compared to all others and since it has not been mapped it will not be gray. If you recognize the flashing pixel add it by clicking on it and pressing the ADD button as described before. If the flasher didn't happen to flash during the capture interval It may be necessary exit **Map Bad Pixels** (without saving) and repeat the **Counts / Delta** function again. When finished, save and exit.

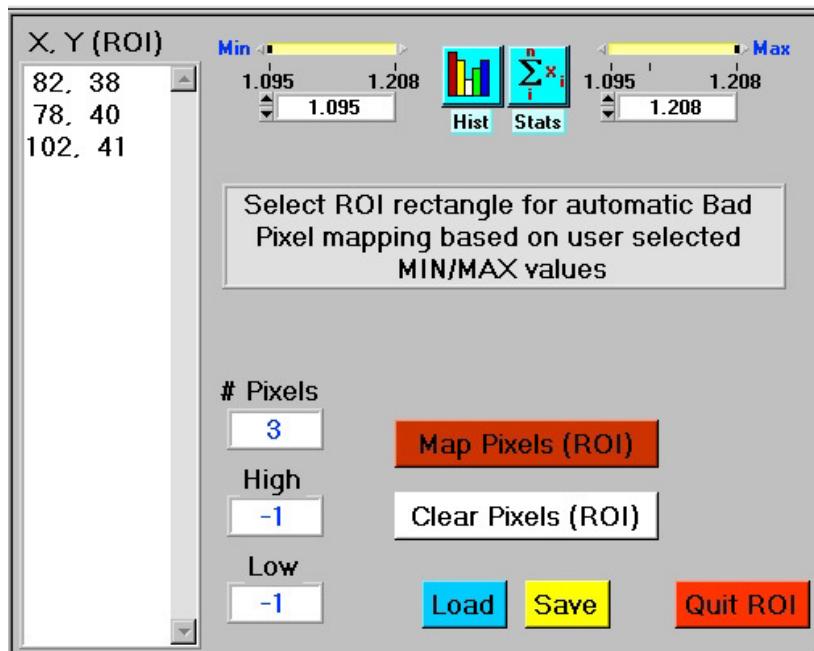
6.3.4.6 Mapping Many Bad Pixels

This procedure assumes that the bad pixel map was lost or for some reason the user wishes to map many bad pixels.

- 1) Install the Radiance Calibration target with the 4 holes on the thermal stage. Set the stage for 70 C and center and focus with the low mag lens on the large hole with at least some of the covering mask in the field of view. The contrast between the highly emissive black body and

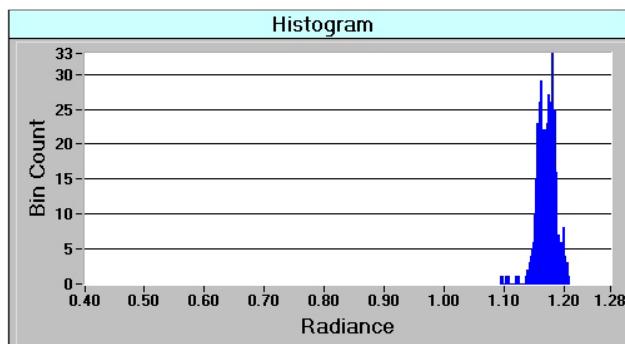
low emissivity cover helps to highlight some marginally bad pixels. Using this target is helpful but not essential to this procedure.

- 2) Begin by initiating **Acquire / Counts / Delta** as in the previous section. This will acquire and display a map of nearly all bad pixels as previously described.
- 3) Launch the **Map Bad Pixel** routine from the **Configure** menu.
- 4) Since we are mapping many bad pixels, choose Auto ROI (Auto Region of Interest). A new dialog box appears.
- 5) Use the IMAQ tools to draw a box around the entire image.
- 6) Choose the Histogram button on the Bad Pixel ROI box. A histogram will appear just above the dialog box.



Map Many Bad Pixels with Auto ROI feature

- 7) Note the example: the good pixels cluster in a distribution. The outliers are the bad pixels. Note the numerical values (may not be the same as this example) that are just outside the



cluster. In the example the values min = 1.0 and max = 1.25 should enclose the good pixels and exclude most of the outliers.

- 8) Returning to the ROI dialog box, type in the min and max values just determined and press the **Map Pixels** button. The proposed result will appear as gray pixels in the image. If you find that you mapped too many or not enough, adjust the min and max values and press **Map Pixels** again. When satisfied, choose Save. and Quit ROI.
- 9) If desired after saving, the box can be redrawn in another location. Recompute the histogram for the new location and map pixels here as well.
- 10) When satisfied, **Save** and **Quit ROI**.
- 11) Save and Quit Map Bad Pixels.
- 12) Press the Rref quick button and with the stage controls move the edge between the high and low emissivity target regions about the field of view to locate any other bad or marginal pixels. Be a little aggressive about mapping bad pixels but avoid mapping large contiguous blocks. If you find additional bad pixels map them with the normal or ROI Bad Pixel routines as appropriate.

6.3.5 Emissivity Calibration

InfraScope's emissivity calibration is a factory calibration and should not be attempted in the field. It requires special emissivity calibration targets, some of which require special storage for preservation. The emissivity calibration should be good for the life of the instrument.

6.4 Periodic Maintenance

6.4.1 Cleaning Objective Lenses

The lenses should rarely need more than dusting with a can of "dust-off" compressed-gas duster or low pressure, house dry nitrogen. Occasionally someone's sample will explode or vaporize during testing, coating the lens slightly with a foreign substance. This procedure details simple routine cleaning. Warning: optical coatings are sophisticated, essential and potentially delicate. For more extensive cleaning or damaged lenses consult QFI.

6.4.1.1 Lens Cleaning Procedure

- 1) QFI does not recommend routine lens cleaning else the delicate optical coatings may be damaged. Clean only when a lens is soiled.
- 2) Remove the affected lens.
- 3) Inspect for pits or severe scratches. Consult QFI if the lens is damaged. Pits or severe scratches can affect the accuracy of thermal mapping.
- 4) Use clean cotton tipped swabs and Acetone (alcohol may suit if acetone is not available). Dip a clean swab in the Acetone and make one only light swipe of the lens surface. Do not scrub.
- 5) Discard the used swab immediately. Repeat with another, discarding after each use, until satisfied.
- 6) Use gentle, clean compressed gas to dry the lens surface from the center first, to the edge. Try not to blow solvent into the interior of the lens assembly.
- 7) Replace the lens.
- 8) Perform the Lens to Lens calibration
- 9) Perform the Radiance Calibration for this lens for each range.

	59 of 70	www.quantumfocus.com Quantum Focus Instruments Corp, Vista, CA USA
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6.4.2 Cleaning the Optical Head

The InfraScope Optical Head should be cleaned periodically by dusting it with gentle, clean compressed gas such as house dry nitrogen or a commercial can of compressed gas commonly sold for dusting instruments.

6.4.3 Poor Dewar Hold Time / Pumping the Dewar

The Dewar holds about 300 milliliters of LN₂ when filled. For a new system that should keep the infrared detector cold for over 8 or 9 hours, sometimes longer. The dewar may keep an 8 hour or longer hold time for years. However it is normal for these Dewars to outgas over time and perhaps even to have minor leaks. They occasionally need re-pumping. For best results QFI recommends that the head be returned to QFI for service when the Dewar needs pumping, but if your facility has a competent high vacuum expert it can be pumped on-site by following this procedure.

6.4.3.1 CAUTION

The Dewar must be pumped with high-vacuum equipment capable of achieving 10^{-6} torr or more vacuum. Pumping the dewar with a relatively low vacuum roughing pump will have undesirable results and may expose the detector electronics to ruinous H₂O condensation. This could be **EXPENSIVE**.

6.4.3.2 Knowing When Pumping is Needed

Pump the dewar only as needed. If the dewar holds for at least 4 hours we do not recommend pumping. 4 hours is enough to last through half a shift. Refill the dewar just before or after lunch and work through the rest of the day. If the hold time is less than 2 hours we recommend pumping urgently. If the hold time is less than an hour we recommend suspending use of the InfraScope until it is re-pumped. Repeated and frequent filling of the dewar will cause the paint on the top of the dewar to lose adhesion and fall off. Also frequent filling and associated LN₂ spills temporarily degrades the accuracy of the InfraScope. Do not frequently top off the LN₂ in the dewar.

6.4.3.3 Required Equipment for Pumping

High vacuum ($>10^{-6}$ torr) high vacuum pump. We use a turbine type pump at QFI and portable leak testers are often suitable.

		60 of 70	www.quantumfocus.com Quantum Focus Instruments Corp, Vista, CA USA
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The Dewar can be vacuum pumped without removing it from the optical head.

Only engage a couple of threads when removing the plug with the dewar.

Dewar Pumping Tool

6.4.3.4 Procedure for Pumping the Dewar

- 1) Make sure the dewar is warm (room temperature) before pumping. A cold dewar acts as a kind of cryo-pump so pumping a cold dewar will defeat the purpose. Note: artificially elevated temperatures may damage the detector. Do not apply heat to the dewar without consulting QFI.
- 2) Attach the pipe port of the dewar pumping tool to your high vacuum apparatus with appropriate tubing.
- 3) Familiarize yourself with the pump out tool. Make sure the seals are clean. Add a little high vacuum grease if necessary. Make sure you can pull and insert the plunger, and turn the screw threads, without excessive force before you attach it to the InfraScope Dewar.
- 4) Loosen the clamp on the tool, remove the cap on the pump out valve on the InfraScope Dewar, attach the tool and tighten finger tight.
- 5) Screw the pump out tool threads into the InfraScope Dewar port plug no more than a few threads. Too much and you will have difficulty getting it off after pumping.
- 6) Turn on your pump and evacuate the apparatus up to the InfraScope dewar. Before opening the InfraScope Dewar verify that you can pump your apparatus up to the dewar to 10^{-6} or less torr.
- 7) When satisfied, slowly pull the plunger and connect the dewar to the vacuum apparatus. It may take a few hours to achieve high vacuum. It may also be necessary to fiddle carefully with the various connections to achieve a high vacuum seal. Pump overnight.
- 8) When satisfied that the vacuum is 10^{-6} torr or better, re-insert the plunger and turn off the vacuum on the vacuum apparatus side of the dewar.

- 9) Unscrew and remove the pump out tool. If you turned it too many turns into the dewar plug, the plug will freewheel and you will not be able to remove the tool without wrecking your hard won vacuum. The writer knows. If so you will have to start over.

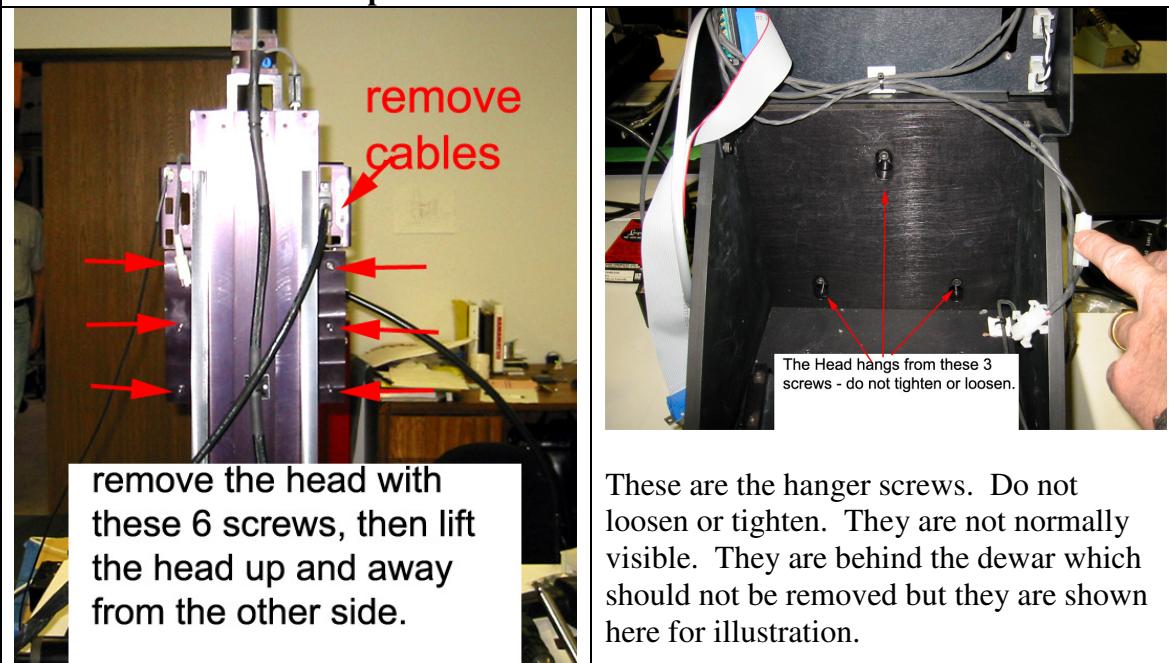
6.5 Packing the InfraScope for Moving or Service

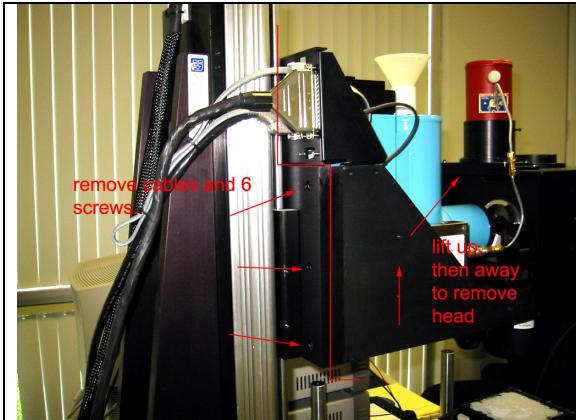
Most of the delicate bits of the InfraScope are in the optical head. Special care should be taken when packing and transporting the head and it should be moved intact, with no other disassembly than removal from the stages.

6.5.1 Removing and Packing the Optical Head

- 1) First prepare a packing carton or container for the InfraScope Head. It should be packed upright with both dewar(s) and lenses attached but if equipped with a trinoc and camera they should be removed. In addition to generous foam all around, there should be a pocket for the lenses and turret. The Head should be bagged to exclude packing material. If you have an InfraScope II, contact QFI, we have a special packing box for the head.
- 2) Before removing the head, gently secure moving parts such as the flip mirror, slides and lens turret with masking tape. Put a bit of tape over the dewar openings to exclude packing material. Remove the electrical cables.
- 3) The InfraScope II and InfraScope 3 head is fastened to the vertical stage with socket head screws (6 for the InfraScope II). When these are removed the head hangs on shoulder screws and may be lifted up and away. The InfraScope 1 (Barnes Design) rests precariously on a metal flat, attached by 4 screws. Get a friend to hold the head while you remove the screws.

Head Removal – InfraScope II





After removing the cables and 6 socket head screws, the head may be removed by lifting up and away from the vertical stage.

- 4) Bag the head and carefully pack it in the previously prepared carton or crate.

5)

6.5.2 Preparing the stages for shipment

Check the InfraScope drawer for shipping locks. If available, attach to the stages. We have never had a problem when omitted, but always a good idea. Remove the thermal stage and pack carefully. If desired, the motion stages may be removed from the baseplate with 4 attaching screws. To access, remove the extruded covers from the lowest stage.

6.5.3 Preparing the Rack and Electronics for Shipment

Tape the drawers and computer door shut. Coil the head cables and lay them gently inside the rack in the back. Remove the stage cables at the stage controllers (3 green or blue electronics boxes). Take special care with the stage connectors, the screws tend to back out easily, releasing the wires. If this happens reassemble using one of the other connectors as a guide. Wrap the entire rack with stretch wrap.

7 Advanced Techniques

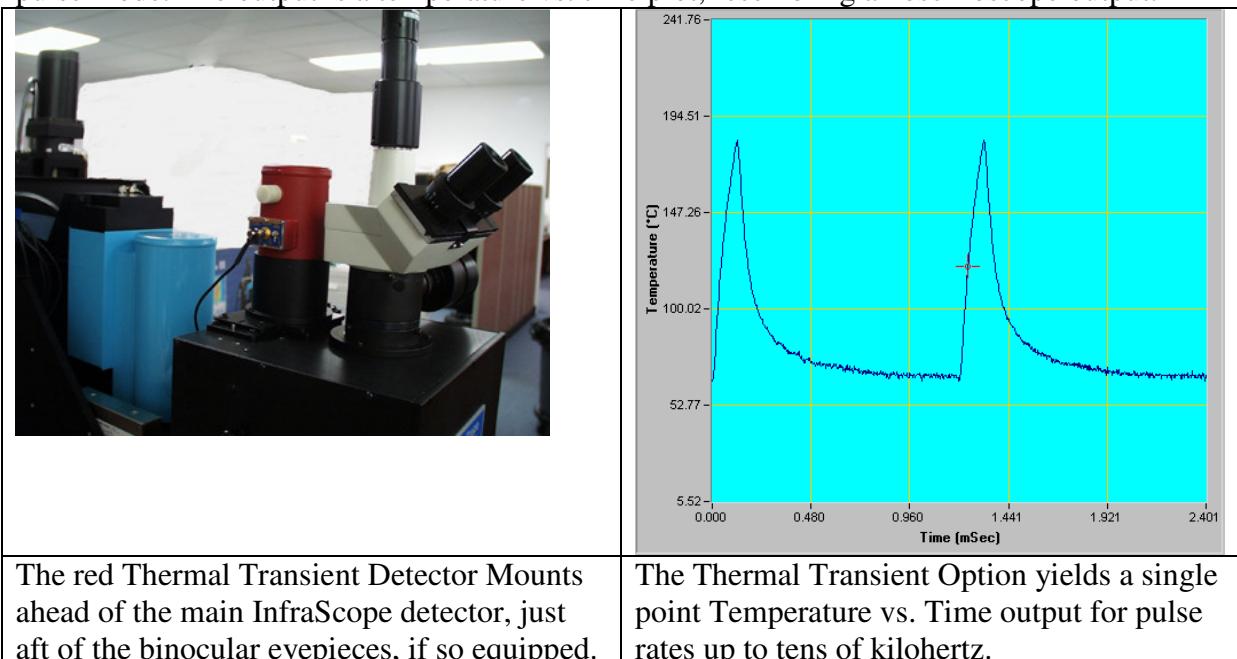
This section is under development.

7.1 Thermal Transient

Please see separate InfraScope Thermal Transient Manual.

7.1.1 Description

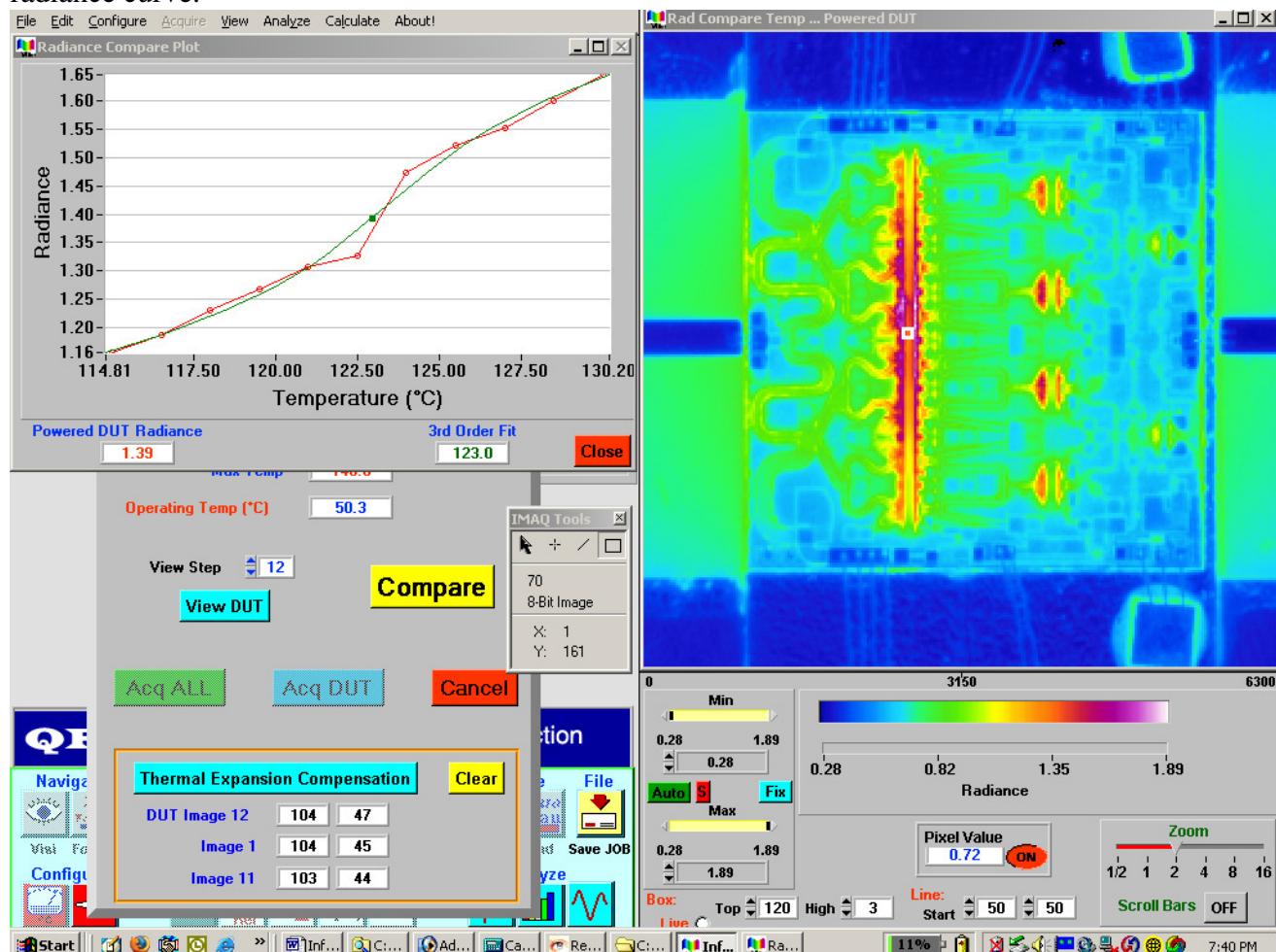
From time to time workers need to measure thermal phenomena that occur and disappear at very high speeds compared to the capture rate of the normal InfraScope array detector. QFI designed the Thermal Transient option to meet these needs. The Thermal Transient offers very high-speed capture of Thermal phenomena at a single pixel, at 10s or 100s of kilohertz. It is commonly used to measure temperatures of e.g., an RFIC, or ink jet device, operated in pulse mode. The output is a temperature vs. time plot, resembling an oscilloscope output.



The main InfraScope detector array may have 250,000 detector elements or more. These must all be read out in sequence, which, together with the associated processing limits the frame time to about 70ms to 100ms. The Transient Detector can operate at much higher speed because it is a single, circular infrared detector coupled to a dedicated, analog transimpedance amplifier. In practice, the capture speed of the Transient is limited by the gain/bandwidth product of the transimpedance amplifier, and by white noise. As shipped the Thermal Transient typically has a 3db roll-off at about 25kHz, stamped on the side of the amplifier. Knowledgeable users may substitute their own amplifiers or use lock in amplifier techniques to extend this bandwidth.

7.2 RADIANCE COMPARISON TEMPERATURE METHOD

The InfraScope Software includes a means, the Radiance Comparison Temperature method, to measure temperatures without computing emissivity. In this technique, the sample being tested serves as a calibration source, whatever its many emissivities. The user captures a sequence of 11 unpowered radiance images at sequentially increasing stage temperatures. For any given region of interest, this generates a calibration curve of radiance vs. temperature that is independent of the local emissivity. The algorithm then compares the local radiance of the powered device, to the unpowered radiance curve.



Radiance Compare Temperature Method Results yield temperature without computing emissivity. Here the box temperature is calculated to be 123 Celsius by fitting a 3rd order polynomial to the radiance curve fitted to the same area by 11 previous unpowered radiance image acquisitions.

The Radiance Compare Temperature (RCT) method has some powerful attraction but it has serious disadvantages to consider as well.

- The temperature spread should be selected to be as narrow as possible to minimize sample expansion and contraction. We typically use a 10° Celsius spread. Often the expansion is still a problem.

- It takes time to adjust the stage through 12 or effectively 13 different temperatures. This is a slow technique and more suited to confirming results than production measurements.
- The RCT works best when interpolating, rather than extrapolating, so the chosen temperature spread should ideally sandwich the expected powered temperature. Sometimes this isn't possible, but it should be attempted.

7.2.1 RCT Procedure

- Start by measuring the sample temperature by the normal means. Use the measured temperature as the mid point for the 10 degree spread for the RCT method.
- Launch the Radiance Compare from the Acquire Menu.
- Adjust the temperature spread, make sure the device is powered off and start the acquisition.
- When the Software prompts for the powered temperature, apply power.
- To view the results, use the View menu and relaunch the Radiance Compare. Outline the area of interest with a box and press the Compare button.
- When finished, the RCT is saved as an RCT file from the File menu.

7.3 2-TEMPERATURE EMISSIVITY METHOD

7.4 OTHER EMISSIVITY METHODS

7.5 AVI capture

7.6 Sample Painting

	66 of 70	www.quantumfocus.com Quantum Focus Instruments Corp, Vista, CA USA
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8 Trouble Shooting

8.1 No Image

Check for LN2. Sad to say, sometimes we get trouble calls because the user forgot to fill the dewar, or didn't fill it full of LN2. When completely full, the LN2 should just dribble slowly out. See the section on filling the dewar in "**Normal Operation**".

On the InfraScope II, check that the vertical flip mirror is in the correct position.

On the InfraScope II, if equipped with the transient option, check that the transient mirror is in the correct position.

Check that the on/off switch on the InfraRed dewar is on. On some models it is a toggle switch at the top of the dewar. On other models the toggle switch is very low, on the right side of the dewar. The dewars often have an LED power indicator.

8.2 Poor Hold Time for Camera LN2

When new and full of LN2, the detector should remain cold for more than 8 hours. After time the dewar may become soft and require re-pumping with a high vacuum pump (1E-6 torr or less). You should service the dewar if the hold time is less than 3 or 4 hours. Do not operate the InfraScope if the dewar hold time is less than 1 hour. See the section on **Poor Dewar Hold Time** in the **Maintenance and Calibration** chapter.

8.3 Flashing Screen / Bad Pixels

If the screen flashes you probably have a new bad pixel of the "flasher" variety. For a temporary fix, press the "Fix" button for image scaling. However it only takes a few minutes to permanently correct the problem. See the section on mapping bad pixels in Maintenance and Calibration.

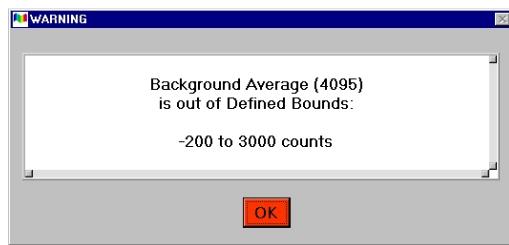
8.4 Pale Images, Color Bar Temperature Range Exceeds expected range.

Pale washed out images or unrealistic temperature ranges are probably caused by a new bad pixel. It may appear permanently hot or cold. It may also be at the extreme edge of the detector array and be hard to see. Fortunately it is easy to correct. Please see the section on mapping bad pixels in **Maintenance and Calibration**.

8.5 Message "Unexpected Counts / Background Counts out of range"

May mean that the dewar is out of LN2.

May mean that the flip mirror or transient mirror is in the way.



Refer to the **No Image** checklist.

8.6 X,Y, or Z stage doesn't move

Before anything else, try a power down reboot of both computer and electronics.

Check the stage connectors on the top of the motion stage controllers in the back of the 19" rack. Sometimes the screws become loose and the wires back out. Use an intact connector for a wiring example.

8.7 Removing persistent drawn boxes and drawn lines from image

For thin border boxes or lines, try single or double clicking in the image area. For thick bordered boxes, uncheck the “Box Live” option just below the scaling options.

8.8 Green On / Off button doesn't work, or Emergency Off button doesn't work.

There is a Pulizzi power distribution box in the back of the rack. It has a 3 position switch, “local” / “off” / “remote”. The emergency off switch and green power button are wired into the “remote” setting of the Pulizzi. If the Pulizzi is turned to local the power will always be on and the green button and emergency off will be disabled.



Check the connectors on the top of the Motion Stage Controller

8.9 Columns in Image / Non-uniformity

A move to a warmer or cooler lab, change of season or periodic natural drift (1/f noise) in the detector array may void the uniformity correction. Perform the uniformity correction as described in the Maintenance and calibration section.

8.10 Lots of red and blue edges in the unpowered or powered temperature image.

The sample moved after the Radiance Reference image was captured, or a hot thermal stage is creating excessive convection currents. This is fundamental to the operation of the InfraScope. Please refer carefully to the **Quick Start** guide or **Normal Operation** section of the manual.

8.11 Wrong Temperature Measurements

Bad temperature readings could be due to a number of possible causes. We discuss this in the Normal Operation section. Probably because the emissivity correction is faulty, which most often is because:

Radiance Reference image was captured at too low a temperature. Try 70C for most materials. Try 80C or 90C for polished gold (low emissivity material).



Input temperature for the Radiance Reference temperature was incorrect for the imaged surface. Sometimes tooling and fixture buildups insulate the sample surface from the RTD temperature sensor embedded in the thermal stage. Use the stage settings to change to External Temperature Control. Measure the surface temperature or nearby approximating area with a thermocouple and type in the temperature when prompted.

8.12 Cutting and Pasting a Screen Image:

To capture the entire InfraScope display, press the “Print Screen” key on the keyboard.

To capture only the infrared image, click once on the image with the mouse to make that window active, then hold the “Alt” key and press “Print Screen”.

Load the image editor; PaintShopPro is supplied with the InfraScope. This may be done from the InfraScope “File” menu or from the Windows Start menu. This should only be done once, do not open a copy of PaintShopPro for each captured image.

Switch to PaintShopPro by pressing “Alt” and “Tab” or with the mouse from the Windows task bar.

In PaintShopPro click on “Edit” and “Paste as New Image” to paste the InfraScope image as a new photo.

Crop, edit or annotate the image as desired using PaintShopPro tools.

To save, click on “File” and “Save Copy As”.

From the pull down menu choose the desired format, we suggest JPEG. In options choose “Lowest Compression Best Quality”.

Choose a location and name and save the image.



8.13 What is the logon password?

If your InfraScope has been networked you must see your network administrator for the password. If it remains as shipped from QFI, the user name is Administrator and the password is blank.

		70 of 70	www.quantumfocus.com Quantum Focus Instruments Corp, Vista, CA USA
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