Microbolometers for Infrared Imaging and 2013 DRS Student Infrared Imaging Competition

George D Skidmore, PhD
Principal Scientist, and
Chief Organizer of DRS Student Infrared Imaging Competition
DRS Technologies
2013 Student Infrared Imaging Competition
Sponsored by DRS Technologies
Overall Top Project Wins $10,000
Most Viral Video Wins $5,000
Top Project at Your School Wins $1,000
(for schools with more than one entry)

How to Enter:
• Have your Faculty Advisor contact Dr. George Skidmore (gdskidmore@drs-rsta.com) at DRS Technologies to enroll your school.
• DRS Technologies will provide your school with a Tamarisk® 320 thermal imaging camera.
• Use the Tamarisk® 320 in a creative way in your senior design or other project.
• Register your team by February 28, 2013.
• Submit your project to DRS Technologies by May 31, 2013.

Who can Enter:
• Students from any discipline are welcome to compete.

What can you Enter:
• Projects could include but are not limited to the following: Image Fusion, Augmented Reality, Robotic Vision, Machine Vision, etc.

About DRS Technologies
• Tamarisk® 320 is the world’s smallest 320 x 240 format uncooled thermal imaging camera.
• DRS Technologies is a world leading supplier of uncooled thermal imaging focal plane arrays.
• For more information about DRS Technologies, go to www.drsinfrared.com.
Developed the first Forward Looking Infrared (FLIR).

Developed the 2nd generation Focal Plane Array.

Developed the Common Module detector.

TI sold its defense business to Raytheon including cooled focal plane technology. Raytheon was required by the U.S. Department of Justice to divest itself of the former TI infrared business, including the infrared focal plane array program.

Developed the 64x64 staring Focal Plane Array (FPA), enabling the Javelin missile fire and forget capability.

1415 Employees between both facilities (525 in Texas, 890 in Florida) in 2010

2010 Revenue approximately $847M
Science and Engineering of Thermal Imaging
Passive Night Vision Technologies

Image Intensification
Visible or Near-Infrared, low-light amplification

Thermal Imaging
Long-Wave Infrared, thermal radiation
Active Night Vision: ~800nm Illumination and Silicon Sensor

Hello and welcome to the EyeClops Night Vision Goggles guide. We are here to bring you the latest EyeClops Night Vision reviews and to help you learn about this great new toy. We are also here to help you find the best places to buy EyeClops Night Vision Goggles online for the lowest prices. So if you are ready, take a look at our review below or check out our demo video.
Electromagnetic Radiation
All objects emit radiation that is dependent on their temperature:

- Sun
- People
- Automobiles
- Etc.
Blackbody Radiation at 300K, 27C, near room temperature

Spectral Radiance, peaks near 10μm:

$$\text{Planck}(T, \lambda) := \frac{\frac{2\pi c^2 h}{\lambda^5 \left(\exp\left(\frac{hc}{kT\lambda}\right) - 1\right)}}{\text{Watts}} \quad \frac{\text{Watts}}{\text{cm}^2 \text{steradian} \text{μm}}$$

Differential Spectral Radiance, peaks near 8μm:

$$\text{DPlanck}(T, \lambda) := \frac{\frac{2\pi c^3 h^2 \exp\left(\frac{hc}{kT\lambda}\right)}{kT^2 \lambda^6 \left(\exp\left(\frac{hc}{kT\lambda}\right) - 1\right)^2}}{\text{Watts}} \quad \frac{\text{Watts}}{\text{cm}^2 \text{steradian} \text{μm-K}}$$

Note: Differential spectral radiance exists from 3μm to greater than 25μm.
Atmospheric transmission

Horizontally, through 1 km of atmosphere at sea-level.
Atmospheric transmission

Visible
0.4-0.7µm
NIR
0.7-0.9µm
Mid-wave (MWIR)
3-5µm
Long-wave (LWIR)
8-12µm or 8-14µm
Uncooled Infrared Camera

- Camera Core: 2 cm
- Detector: 2 cm
- UFPA or Die: 1 cm

- 17 microns
Microbolometers

1. Isolated Microbridge Structure
   absorbs IR radiation, temperature increases rapidly

2. Supporting Leg
   provides electrical contact & thermal isolation

3. Temperature Sensitive Transducer Material (VOx)
   temperature rise causes resistance change

4. CMOS Pixel Readout Circuitry
   converts resistance change into electrical signal
Video output

- Response: image “brightness”: (mV/K)
- Noise: “static” (uV)
- NETD (mK)
Figures of Merit

- Response is not a good figure of merit (FOM)

- Noise equivalent temperature difference (NETD)
  - Output noise (μV) / Response (mV/K)
  - Temperature difference of scene objects that produce a response at the noise level – smaller is better

- Thermal time constant (TTC)
  - Time for the pixel to reach 1/e of a scene induced temperature swing – also desired to be small

- NETD * TTC is a less-invariant metric
• Analog video out


• Analog video out still
• Full interface documentation available on CD
• Camera Control Software on CD (Windows based)
  • Manual gain and offset
  • One-point non-uniformity correction on command
• 14-bit digital video available, but students have to do some work
Applications

• Military markets
  – Thermal weapon sights
  – Driver’s vision enhancement
  – Night Vision Goggles
  – Unmanned Aerial Vehicle

• Commerical markets
  – Security and Surveillance
  – Thermography
    • Machine maintenance
    • Home inspection
    • Stud-finding
  – Automotive
  – Firefighting / Police
Thermal Weapon Sights (TWS), Drivers Vision Enhancers (DVE)

http://www.drs.com/Products/RSTA/index.aspx
WatchMasters, Surveillance

- **WatchMaster IP Elite**
  - One Cable: Video over IP, Power over Ethernet

$1999
Industrial Thermography

Watch Fluke Ninja video at: https://www.youtube.com/watch?v=zKfruenODT8
Head-up display alerts driver of potential danger ahead.

Pedestrians in path of vehicle.

Critical Image and Warning information to driver.
Automotive, BMW dynamic light-spot

• Comparison of visible imagery to thermal imagery (still images or video) where the thermal imagery had a clear advantage

UT Arlington, 3rd Place
http://www.youtube.com/watch?v=jufdR-S34Q4&feature=youtu.be

Florida Institute of Technology, Oktocopter UAV, Finalist
http://www.youtube.com/watch?v=JDfeGtGi7sA

University of Texas at Dallas, Velocity Tracker, Finalist
http://youtu.be/oLhKHiuDbSo

OK State, Cold Plasma
http://youtu.be/yVgaDkhZlxM

Ohio, IR for Apples
http://www.youtube.com/watch?v=7dHmo7J1OBU&feature=youtu.be

Ohio, Sean Krupa and Brett Ragozzine
http://www.youtube.com/watch?v=AtSv5TNQVjs

UCLA, Respiratory Rate
http://www.youtube.com/watch?v=iLU5a3KAaRQ

Memphis,
http://www.youtube.com/watch?v=TWEKVkuu9wc
http://www.youtube.com/watch?v=ulupwYtqa3Y

University of Michigan
http://youtu.be/D6T94ikRHZ8
http://youtu.be/TELgFmDA9io
http://youtu.be/QLrh81vZtbY
http://youtu.be/COBKjG-728

Johns Hopkins, BBQ
http://youtu.be/TdeNydO5aic

UNC Charlotte
http://youtu.be/lCQ7yGKeQNw
2012 Contest Winners

1st

Counterfeit Money Detection Using Infrared Radiation
Performed By
David Blix, David Campisi, Tyler Canup, Cody Fernandez, Micah Lies
Department of Electrical and Computer Engineering
The University of Memphis
Faculty Sponsors
Dr. Aaron Robinson, Ph.D.; Mr. Thomas E. Wyatt, P.E.

2nd

PROFILOMETRY OF DARK OBJECT USING MOIRÉ TECHNIQUE IN INFRARED

Mehrdad Abolbashari
Gelareh Babaie

Advisor: Faramarz Farahi

3rd

HUMAN TRACKING USING THERMAL IMAGING IN CONJUNCTION WITH AN AUTONOMOUS GROUND VEHICLE

Project Submission in response to
DRS INFRARED IMAGING CONTEST
Department of Electrical Engineering
University of Texas at Arlington
www.uta.edu/ee

Team: Isura Ranatunga, Joe Sanford, Nahum Torres

Sponsor: Dr. Dan Popa
Next Generation Systems Research Group
http://ngs.uta.edu, popa@uta.edu

http://www.youtube.com/watch?v=jufdR-S34Q4&feature=youtu.be
Contest Overview

- Top Prize from all Winning Entries -- $10,000
- Most Viral Video -- $5000
- Top Project from each school (for schools with multiple entries) -- $1,000

How to Enter:
- See Prof. Kinzel
- Register your team by Feb 28, 2013
- Using the camera in a creative way, create your project or video
- Submit your project George Skidmore at DRS Technologies BEFORE midnight on May 31, 2013

Who can Enter:
- Any enrolled students

What format can you enter:
- Video. Powerpoint. MS Word. pdf. Other???
- Most popular was .pdf with link to YouTube video.

Round One Judging starts June 1, 2013
Finalists Presentations and Awards Ceremony – late June 2013
Tamarisk™ 320 Camera

Tamarisk™ 320

The world’s smallest uncooled thermal camera.
# Tamarisk™ 320 Features, contest cameras

## Focal Plane Array

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor Type</td>
<td>Uncooled VOx Microbolometer</td>
</tr>
<tr>
<td>Array Format NTSC</td>
<td>320 x 240</td>
</tr>
<tr>
<td>Pixel Pitch</td>
<td>17 µm</td>
</tr>
<tr>
<td>Spectral Band</td>
<td>8 - 14 µm</td>
</tr>
<tr>
<td>Sensitivity (NEdT) @ f/1.0</td>
<td>&lt; 50 mK</td>
</tr>
<tr>
<td>Frame Rates</td>
<td>30 Hz</td>
</tr>
</tbody>
</table>

## Video Features / Outputs

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog Video</td>
<td>NTSC (480i)</td>
</tr>
<tr>
<td>Digital Video</td>
<td>14-bit/8-bit LVCMOS, or CameraLink®</td>
</tr>
<tr>
<td>Gain/Level Control</td>
<td>Manual or Auto</td>
</tr>
<tr>
<td>4X Digital Zoom</td>
<td>none</td>
</tr>
<tr>
<td>Image Control</td>
<td>none</td>
</tr>
<tr>
<td>Non-Uniformity Correction</td>
<td>1-point with shutter, 1-point no shutter</td>
</tr>
<tr>
<td>Time to First Image</td>
<td>&lt; 3 sec</td>
</tr>
</tbody>
</table>

## Size

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camera Body Envelope H x W x D</td>
<td>29.8 x 25.6 x 29.8 mm</td>
</tr>
<tr>
<td>(includes VPC/FB, no lens)</td>
<td>1.17 x 1.0 x 1.17 inches</td>
</tr>
</tbody>
</table>
ASIC (ROIC) Substrate
Analog/CMOS

Define sacrificial layer

Deposit dielectric and VOx

Deposit umbrella

Release etch