UK Industrial Vision SWIR Challenges

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ALRAD IMAGING
ALRAD INSTRUMENTS LTD

ALRAD - Company Profile

- **ALRAD** are a Distribution company for Imaging, Electro Optic, Analytical Components and Instruments including:
  - CCD and CMOS cameras
  - Frame Grabbers and Digital Acquisition Cards
  - LED and Laser Lighting for Machine Vision
  - Imaging and Image Processing Software
  - Optics, Lenses
  - Linear and Area Sensors
- Trading since 1970, 47 years in business.
- Three divisions – Imaging, Photonics and Electronics

- UK Industrial Vision Trade Association
- www.ukiva.org
- Vision In Action
  Association News
- Machine Vision Conference
  Arena MK 16th May 2018
- www.machinevisionconference.co.uk

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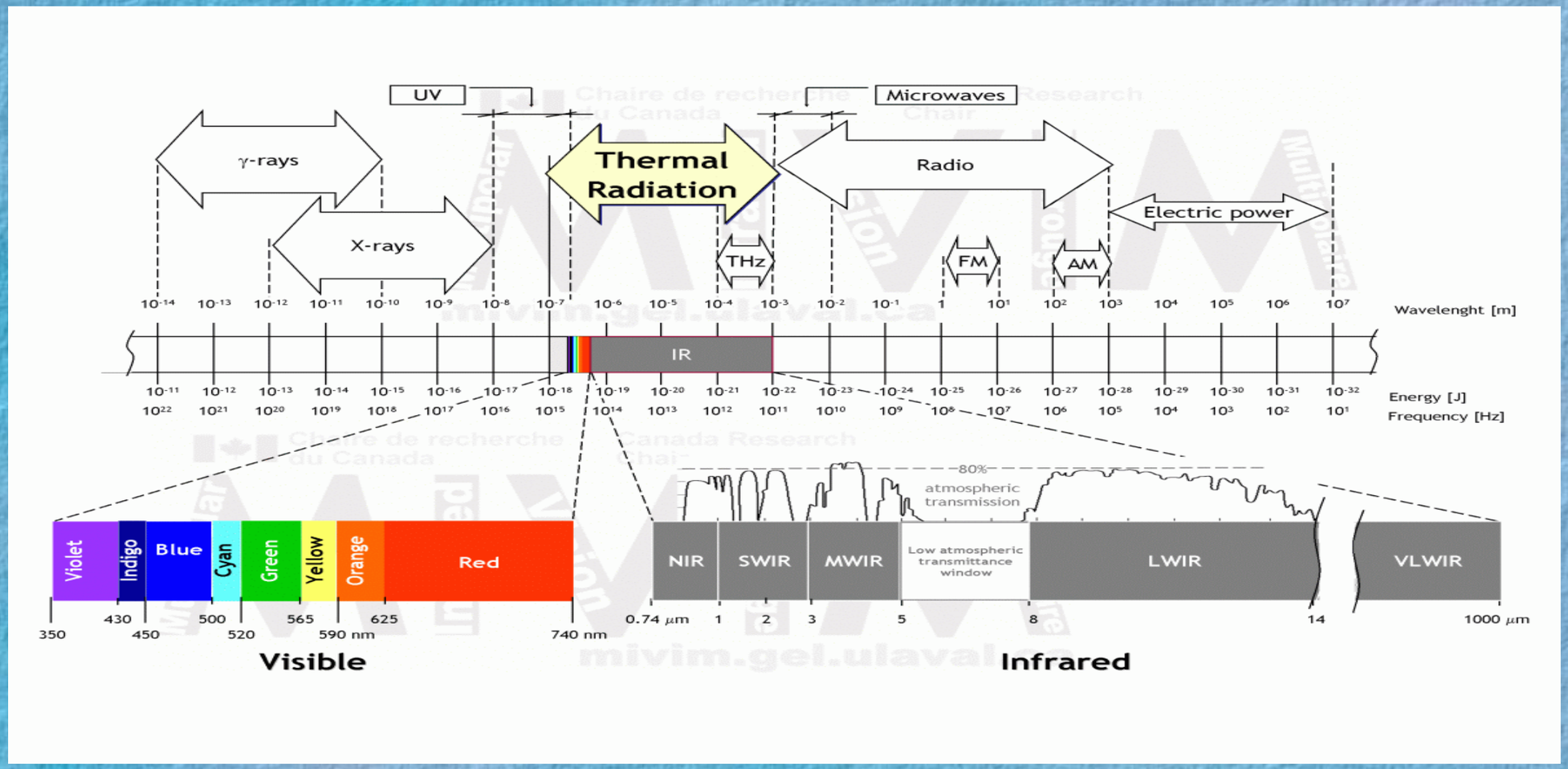
Spectrum



SWIR vs Visible Imaging

- **Historically, solid state area vision sensors are classified as "format" or "type", typically 1/2”, 1/3”, 2/3” and 1”, originally from the front size of a camera tube.**

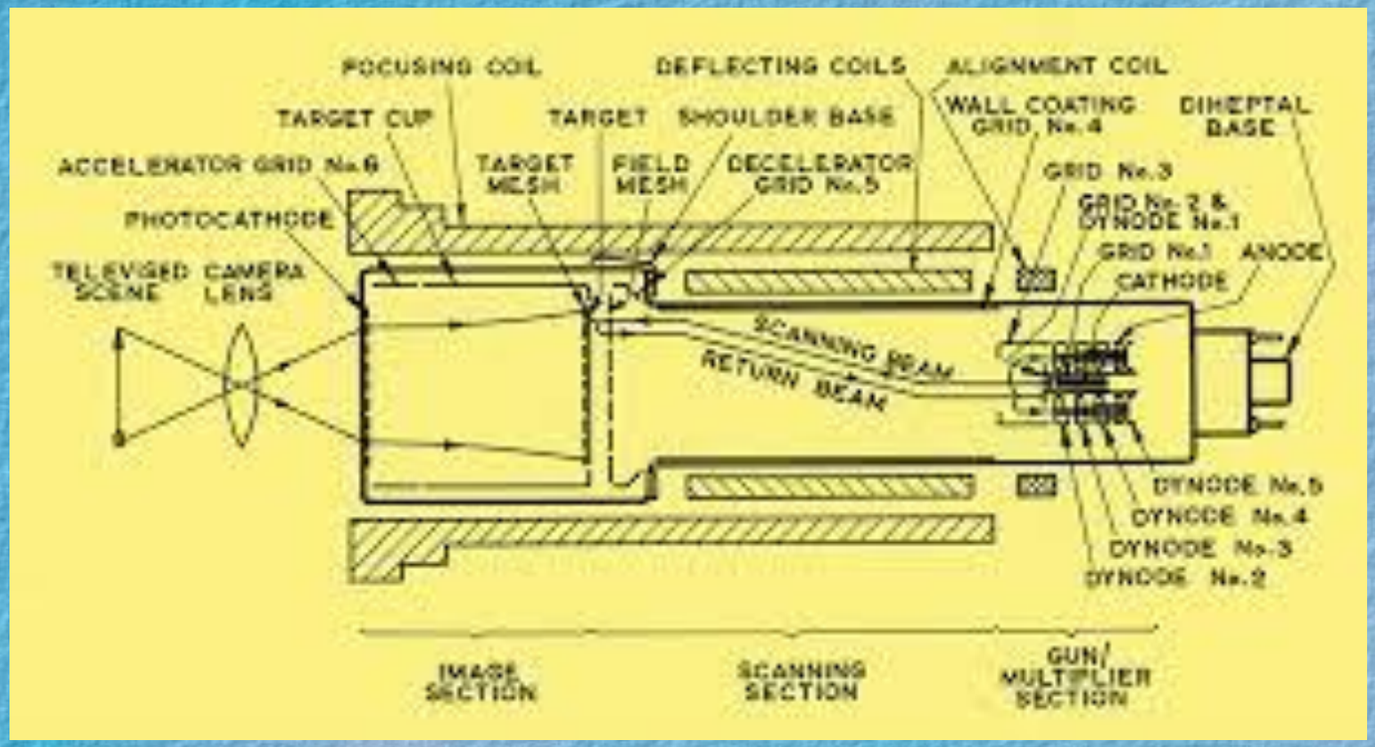
- **With the advent of the latest CCD and CMOS sensors, new sensor formats appeared, e.g. 1/ 2.5” 1/1.8” 1/1.2”, as well DSLR and 35mm film equivalents, with different size ratios and pixel sizes. Machine vision systems are now have higher frame rate and resolution available with faster processing and overall system costs have reduced dramatically.**
- **In SWIR the costs have increased as what was a simple replacement camera tube faceplate is now InGaAs or other technologies at significantly higher cost that Silicon sensors and lower resolution than Current CMOS sensors used in most machine vision applications.**

Camera Tubes – Vacuum Devices

Different Camera Vacuum Tube Sensor
with dimensions in mm to illustrate the correlation of
Imperial Format Types.

Typical sizes for camera tubes were:
1/2”, 2/3” & 1” diameter.

Different Tubes

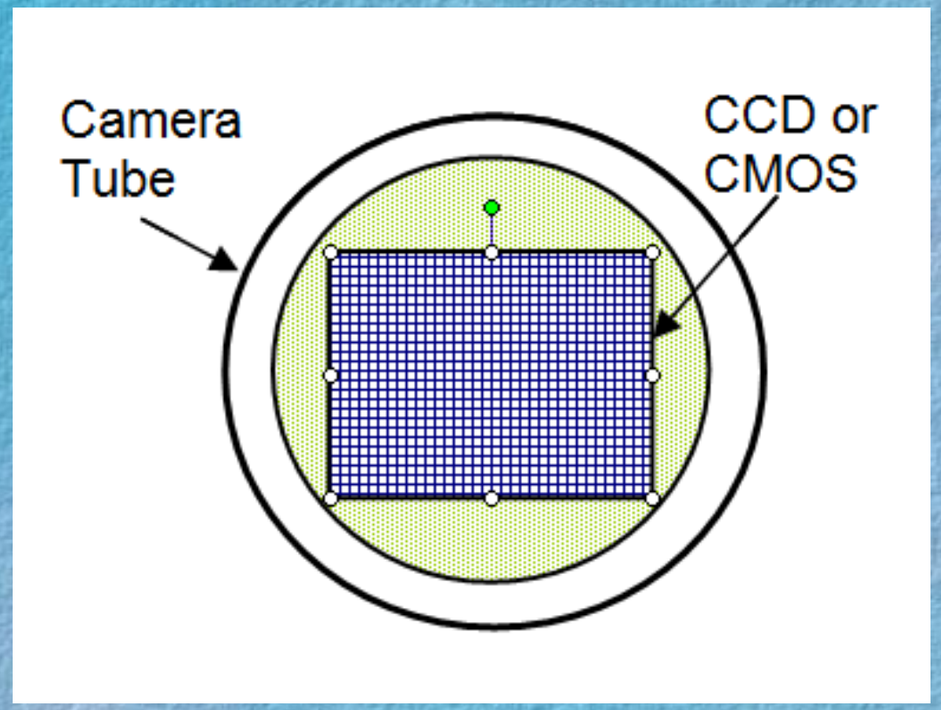


Internal layout of Camera Tube.

Small Cameras!

A compact CCTV camera with 2/3” camera tube. VS CMOS 4 megapixel USB 2 Camera

The origin on the Sensor Format



Face view of a Camera Pick-Up Vacuum Tube Sensor
with a sensor superimposed on the imaging face,
to illustrate the correlation of Imperial Format Types.

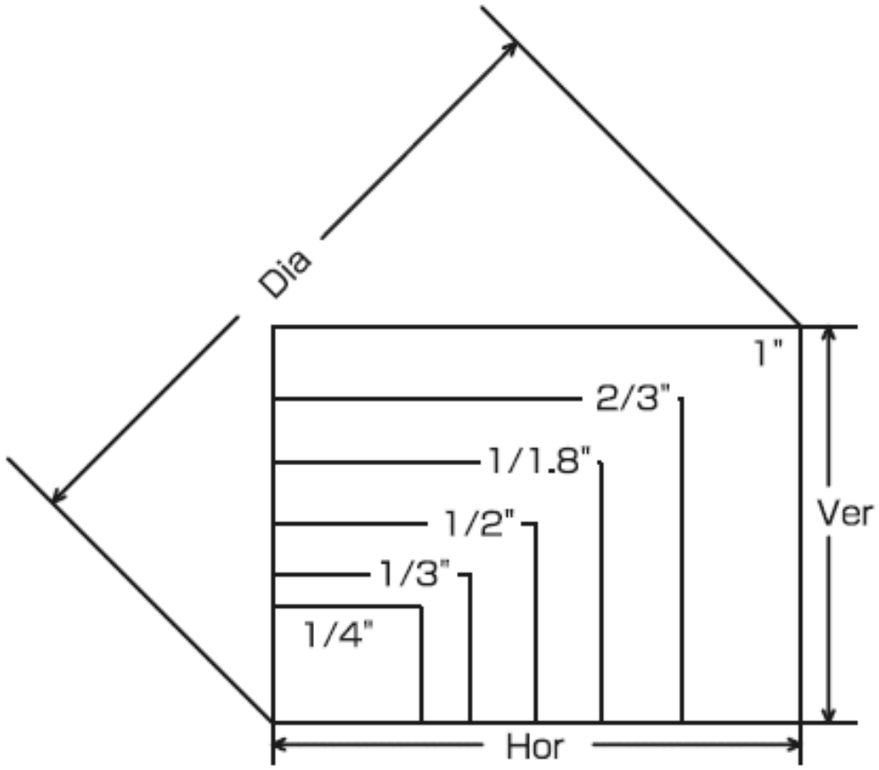
Typical sizes for camera tubes were:
1”, 2/3” & 1/2” diameter.

Different Tubes

Face view showing some different faceplates.

Common sensor formats and dimensions

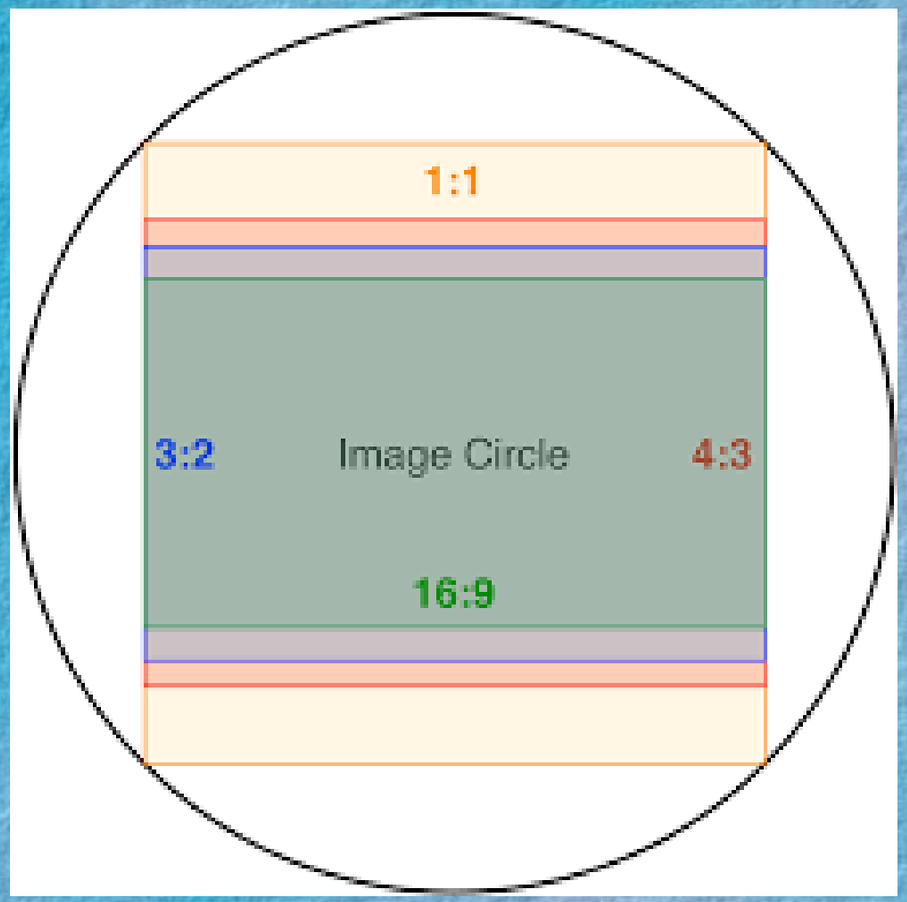
Camera	Hor.(mm)	Ver.(mm)	Dia.(mm)
1/4 inch	3.6	2.7	4.5
1/3 inch	4.8	3.6	6
1/2 inch	6.4	4.8	8
1/1.8 inch	7.2	5.4	9
2/3 inch	8.8	6.6	11
1 inch	12.8	9.6	16



Extended table of sensor formats

Format Type	Aspect Ratio	Ø Dia. (mm)	Diagonal mm	Width mm	Height mm
1/10"	4:3	2.54	1.60	1.28	0.96
1/8"	4:3	3.175	2.00	1.60	1.20
1/6"	4:3	4.762	3.00	2.40	1.80
1/4"	4:3	7.056	4.500	3.647	2.706
1/3.6"	4:3	7.056	5.000	4.000	3.000
1/3.2"	4:3	7.938	5.680	4.536	3.416
1/3"	4:3	8.467	6.000	4.800	3.600
1/2.7"	4:3	9.407	6.721	5.371	4.035
1/2.5"	4:3	10.160	7.182	5.760	4.290
1/2.3"	4:3	10.836	7.66	6.17	4.55
1/2"	4:3	12.700	8.000	6.400	4.800
1/1.8"	4:3	14.111	8.923	7.163	5.438
1/1.7"	4:3	14.941	9.500	7.600	5.700
1/1.6"	4:3	15.986	10.07	8.08	6.01
2/3"	4:3	16.933	11.000	8.800	6.600
1"	4:3	25.400	16.000	12.800	9.600
4/3"	4:3	33.867	22.500	18.000	13.500
1.8"	3:2	45.720	28.400	23.700	15.700
35mm Film	3:2	n/a	43.300	36.000	24.000

Aspect Ratios, Image Circle, Sensor Size



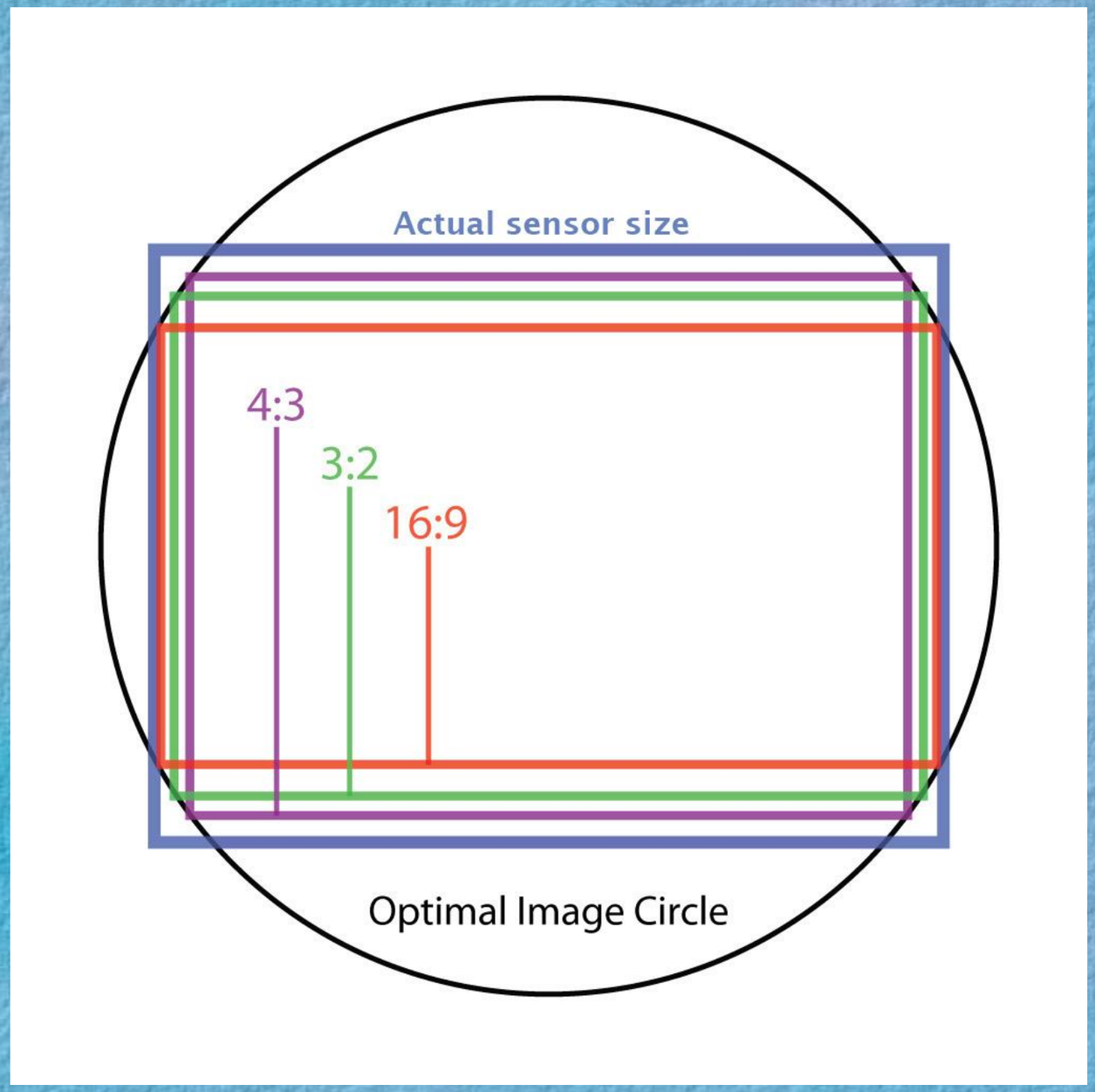
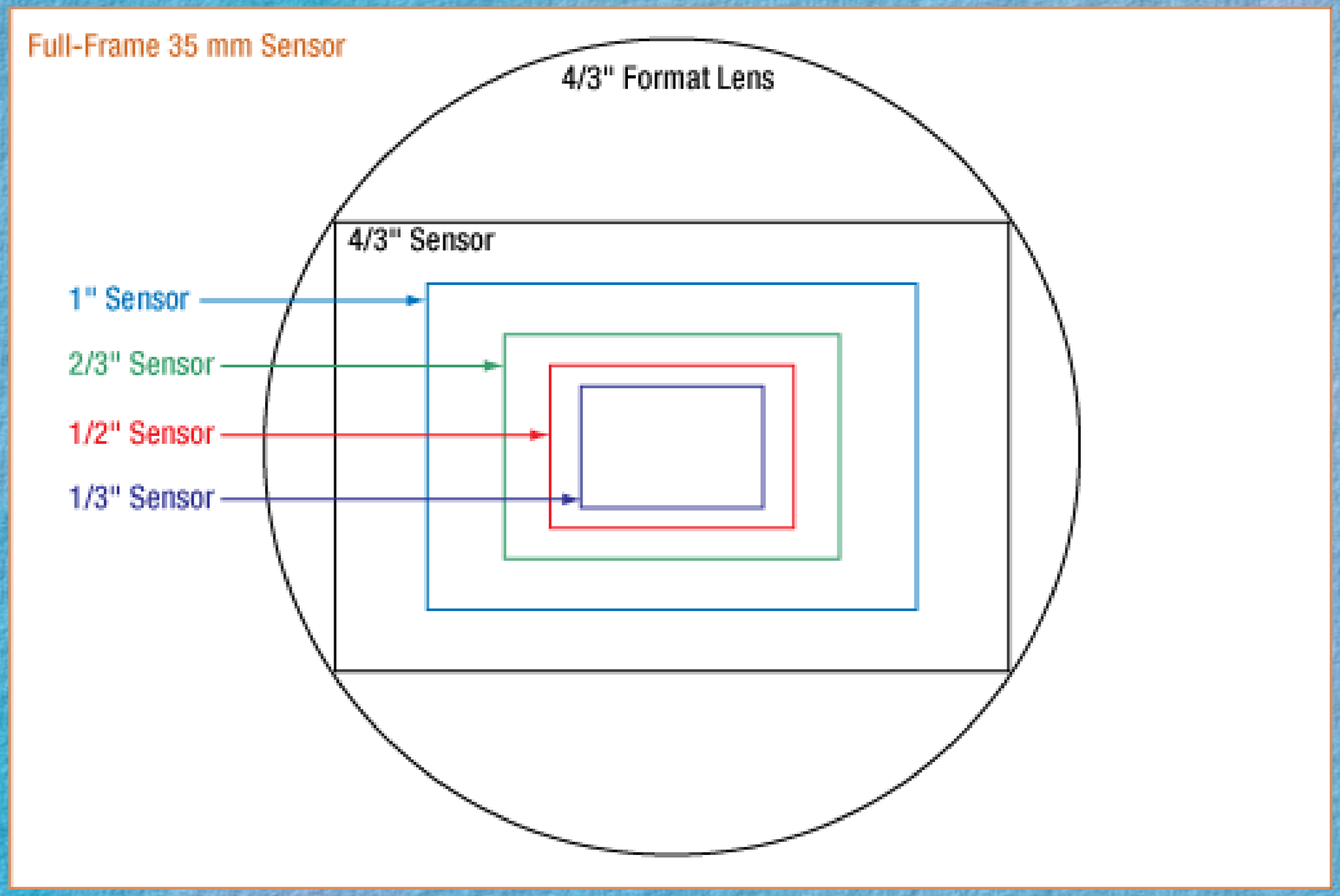


Image Circle vs. Sensor Format



Linear CMOS VS. NIT HDR Logarithmic Sensor

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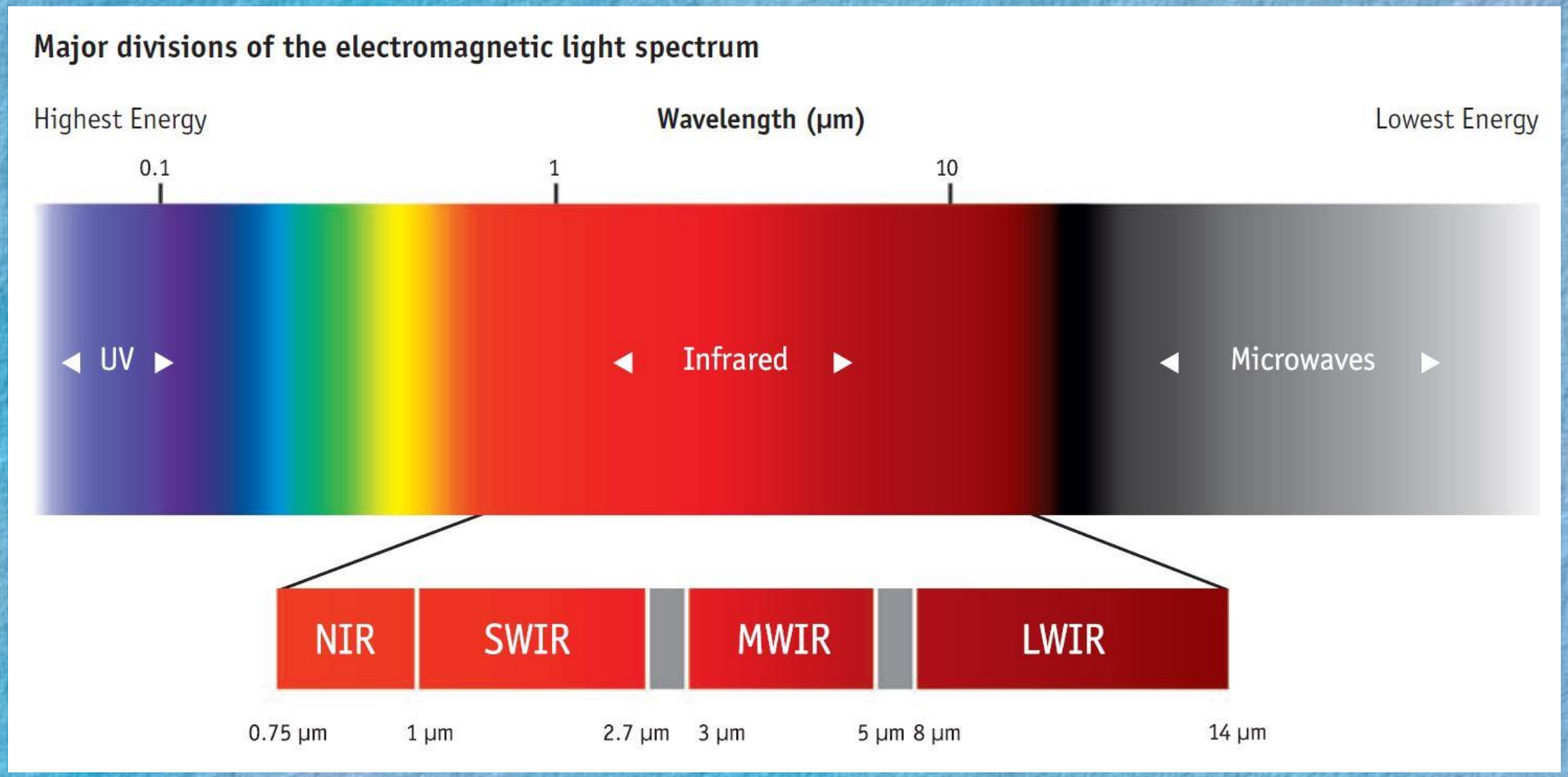
What is IR



WiDy SWIR

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Benefits of SWIR

- Images are **perceived like in the visible** (reflected light)

=> contrasts, shadows easily understood by user

- **Glass lens transmission is possible** (not in thermal bands)
- **Some plastics or inks are transparent**
- High temperature and some lasers are visible

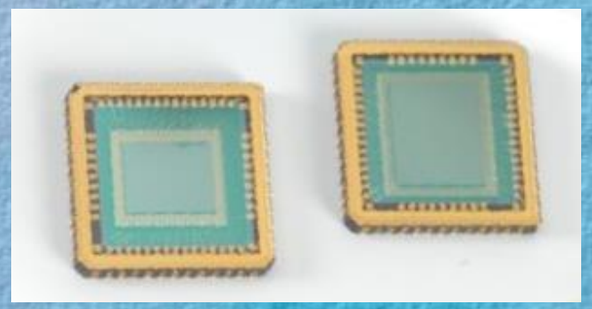
Inspection

Fight against counterfeiting

Liquid level

InGaAs SWIR sensors for WiDy cameras

Sensor Model	Sensor Resolution	Pixel size	Sensor size	diagonal	format
NSC0803 Rolling Shutter	320(H)x256V) QVGA	25 µm	8.00x6.40 mm	10.24 mm	1/1.6in
NSC1201 Global Shutter	640(H)x512(V) VGA	15 µm	9.60x7.68 mm	12.29 mm	1in



AUTOMATIC WELDING

1 MORE ACCURATE AUTOMATIC WELDING SYSTEMS

2 HUMAN ASSISTED VISUALISATION STILL NEEDED

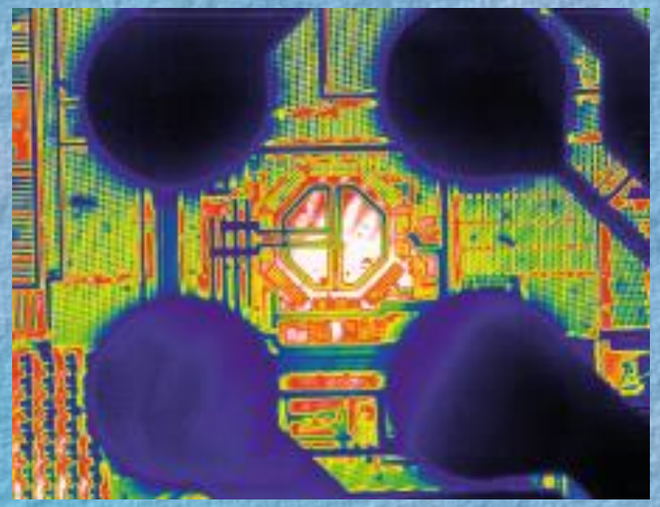
3 SEING DETAILS IN EXTREMELY HIGH ILLUMINATION SCENE

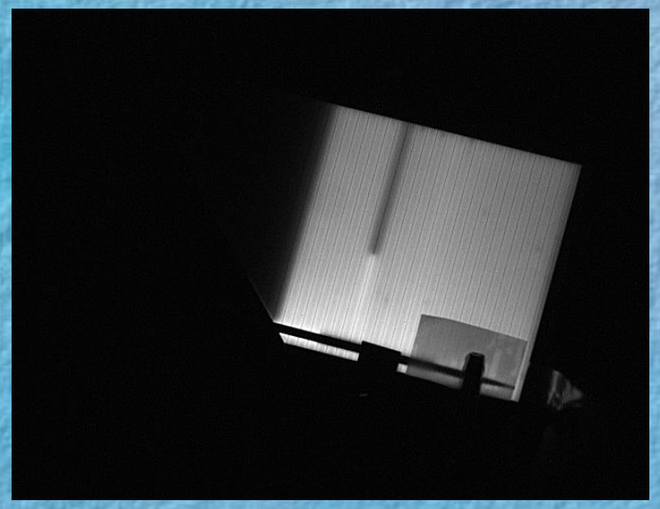
4 HDR IS A MUST

COURTESY XIRIS

Semiconductor

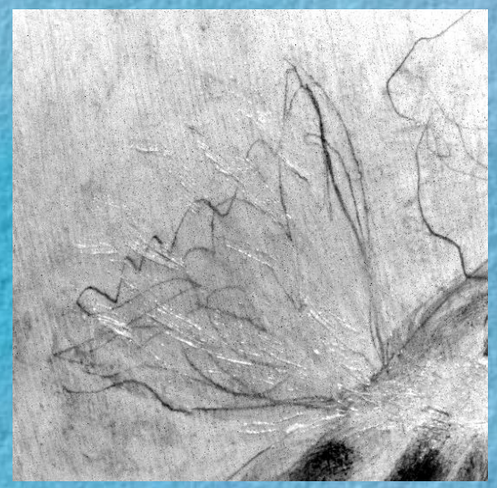
- Solar Cell, Microscopy, Inspection
- See Through Silicon or Micro-Packaging
- Low Power Consumption and Form Factor
- Wafer Test , Alignment or Dicing





Art Inspection

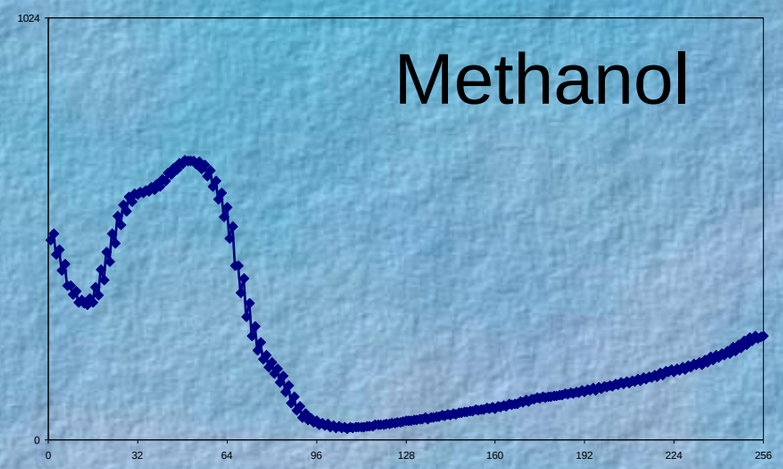
- Counterfeit detection/ Masterpiece Authentification
- Art Education
- Portable SWIR camera connectable to laptop or tablet
- Turn key (No set-up, no additional lighting)

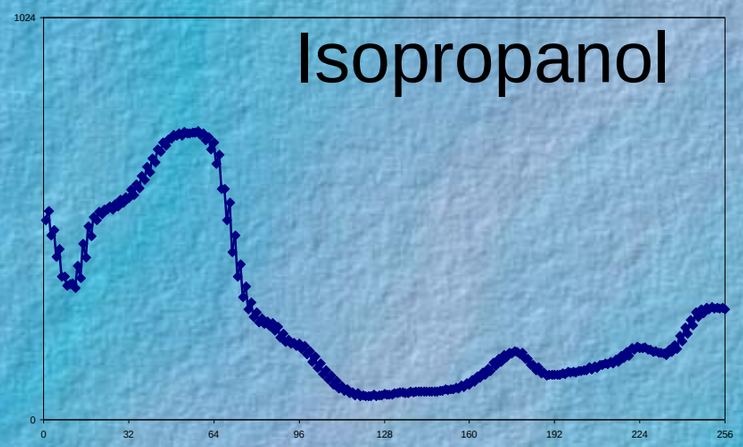


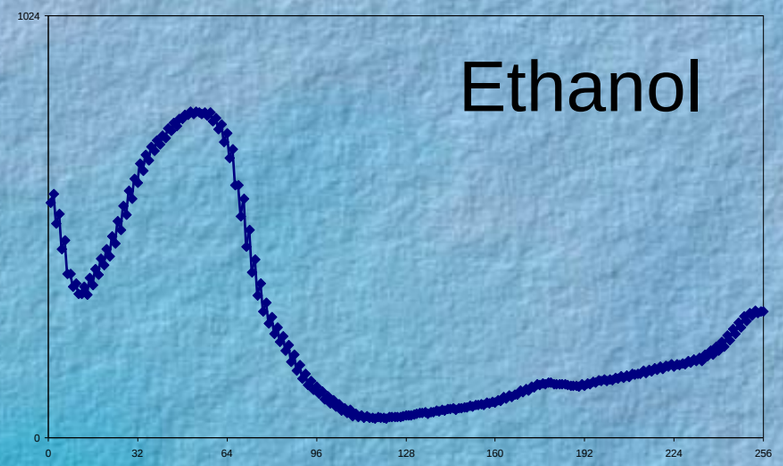
Surveillance

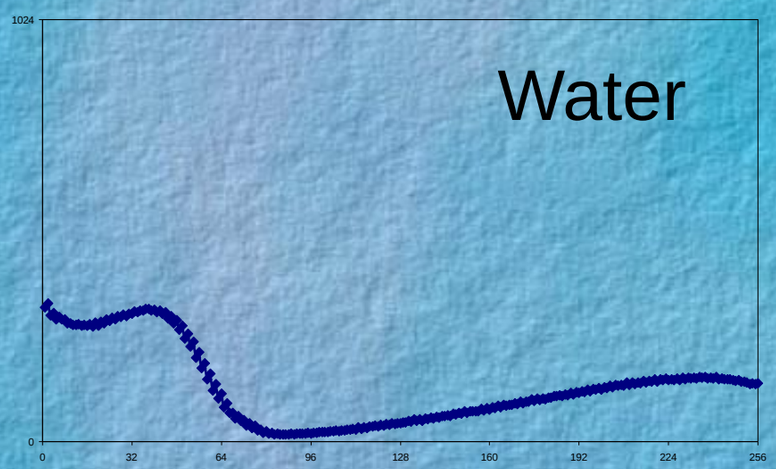
- See through Smoke, Haze, Pollution
- The longer distance, the better SWIR performs versus visible
- Maritime, Border Control, UAV
- Active imaging
- Water, Ice detection

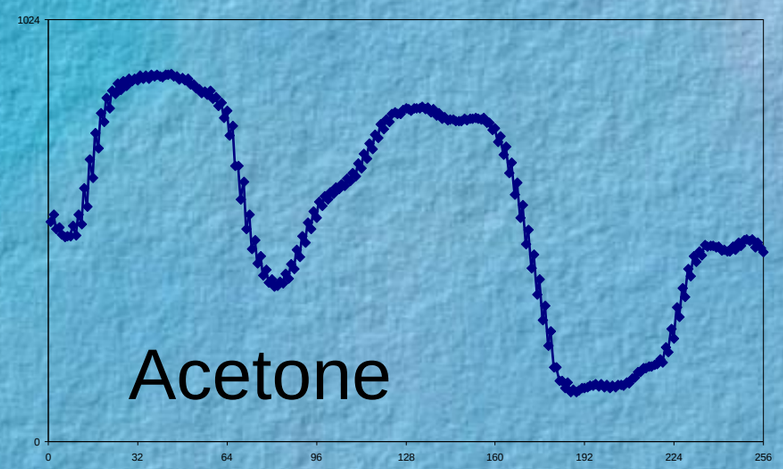
NIR Spectroscopy









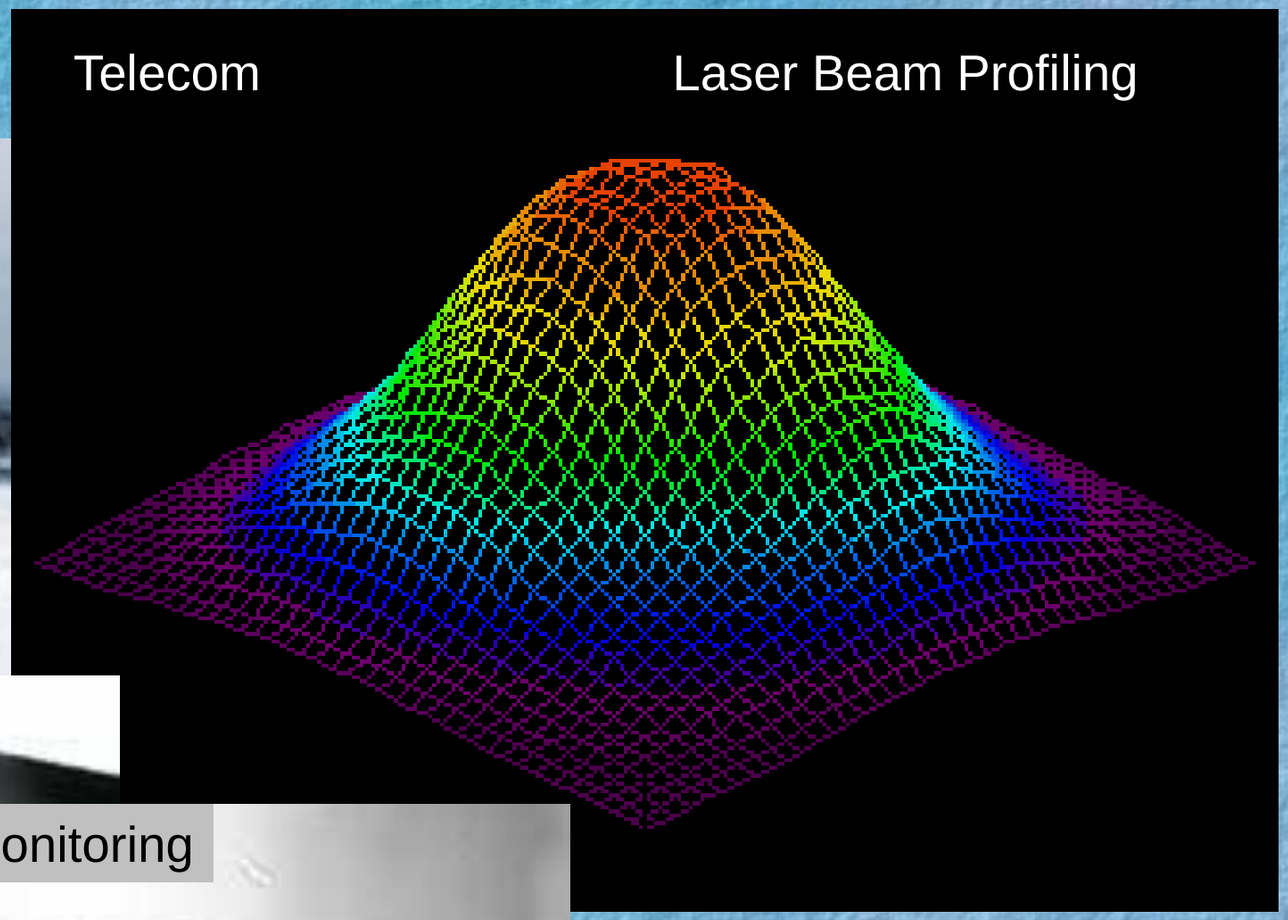


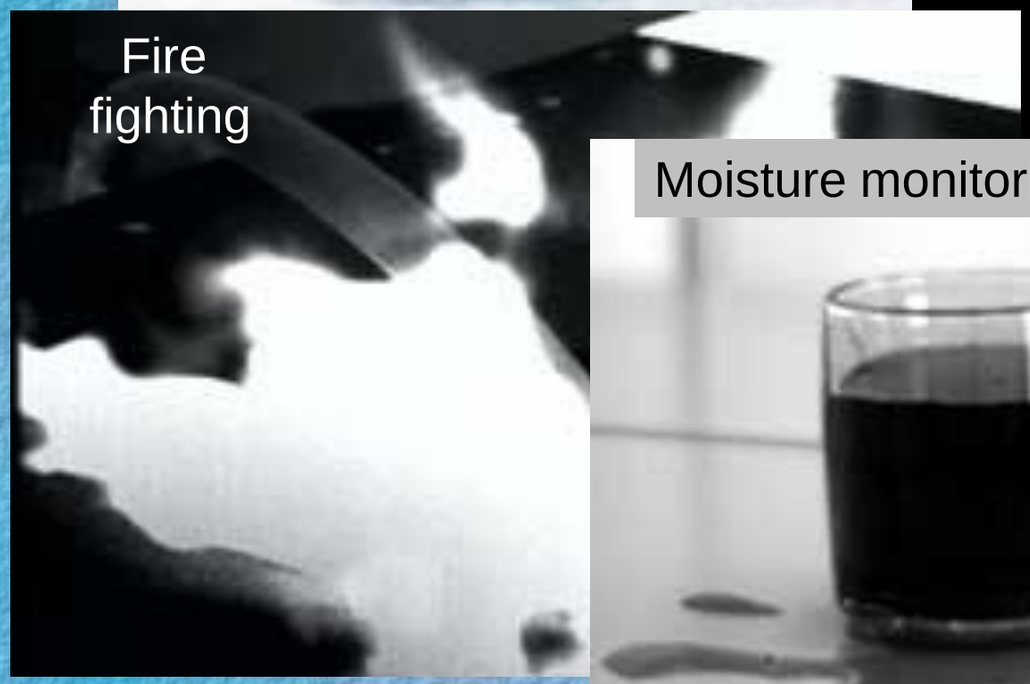
Near-IR Spectroscopy & Imaging

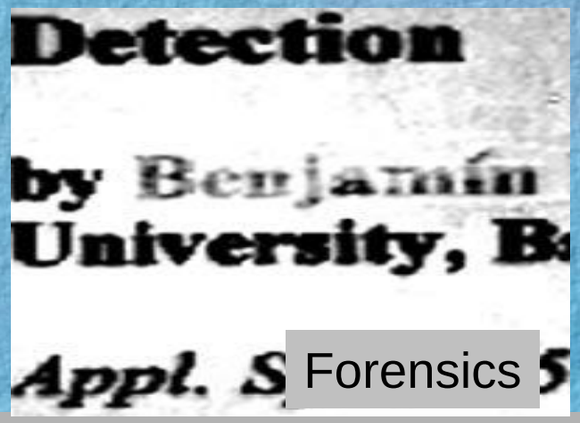
NIR Imaging & Spectros-copy

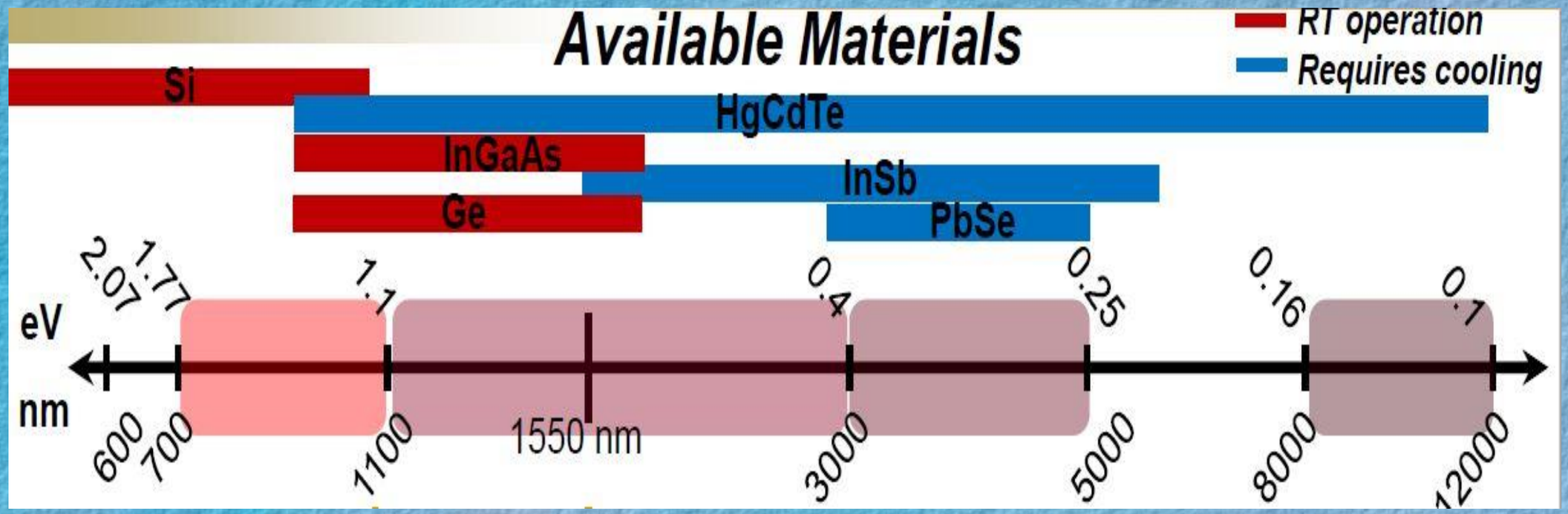
- Telecom
- Food & Agriculture
- Night Vision
- Petro-Chemical
- Semi-conductor
- Cosmetics & Pharmacy
- Glass Textile Plastics
- Forensics
- Medical

Near-IR Imaging








Available Materials
RT operation
Requires cooling
Si
HgCdTe
InGaAs
InSb
Ge
PbSe
eV
2.07
1.77
1.1
0.4
0.25
0.16
0.1
nm
600
700
1100
1550 nm
3000
5000
8000
12000

The Future

- **Black Silicon : commercial developments have been going on since 2012 but no specific lower cost SWIR products on the market yet – modified silicon sensor.**

- **Graphene : 300 – 2000 nm but is a layer on standard silicon sensor using CMOS read out circuits.**

- **Organic Photodetectors : only just beyond silicon with response at 1000 nm but working on SWIR.**

- **SWIR could become much more acceptable if the right material is found or Germanium or specifically InGaAs costs reduce with volume increasing to a lot nearer to that of Silicon sensors.**

Water in clear plastic and glass viewed with SWIR

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