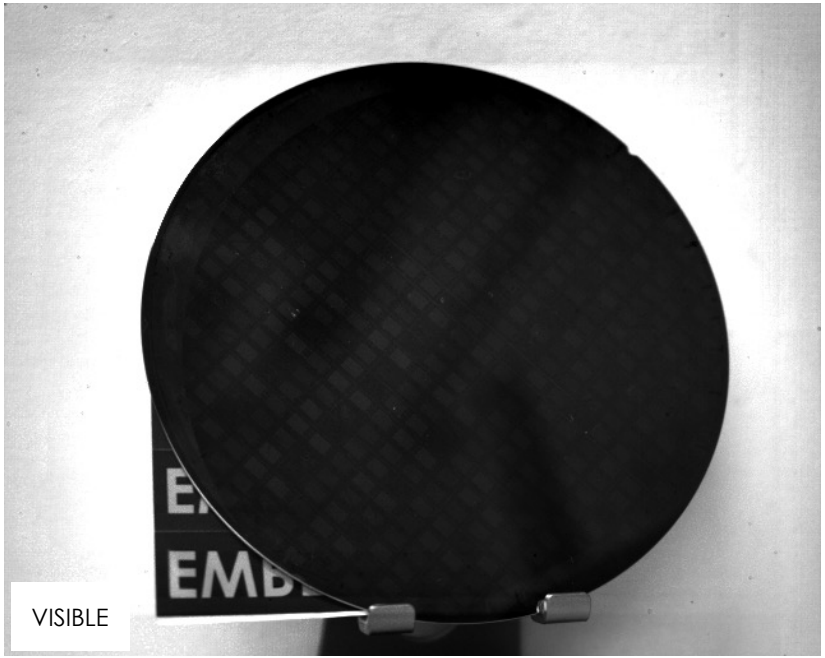
EMBERION

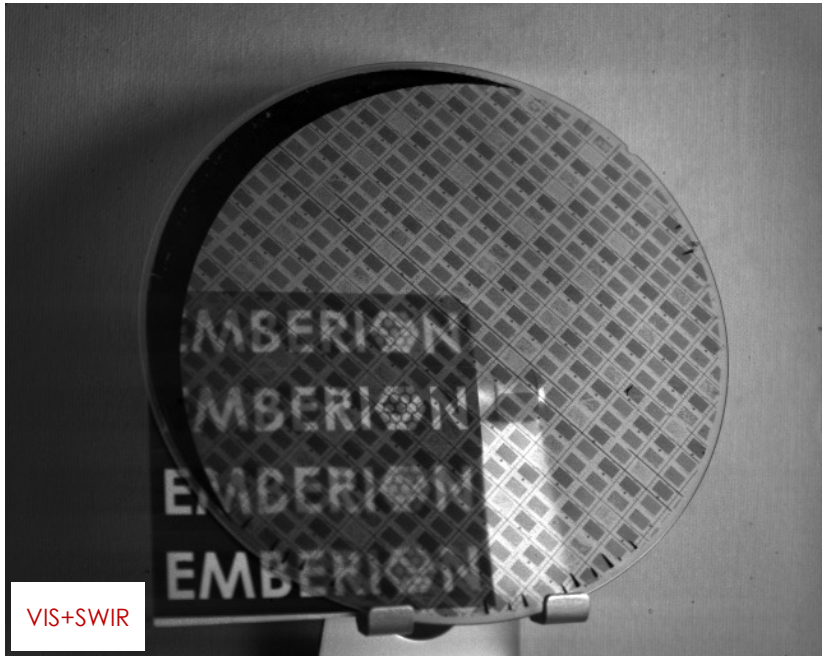
APPLICATION IMAGES

29.02.2024

See through Si-wafer

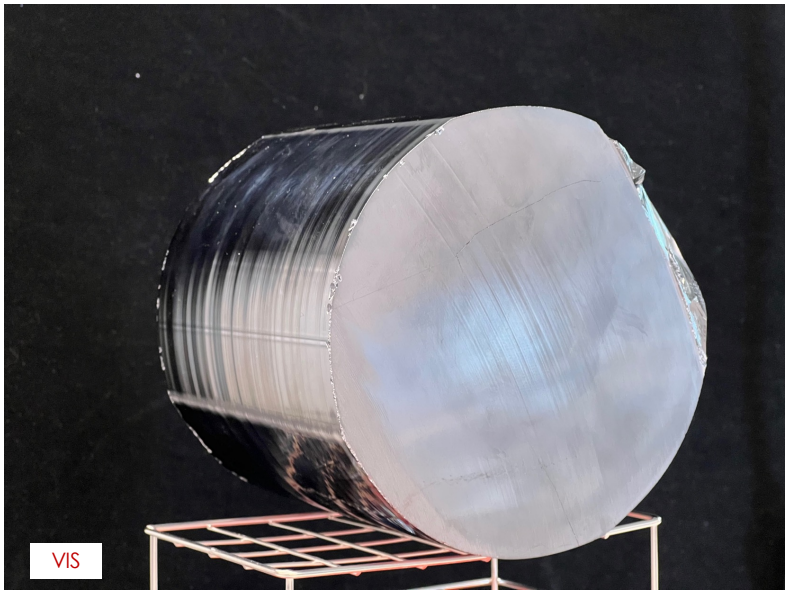


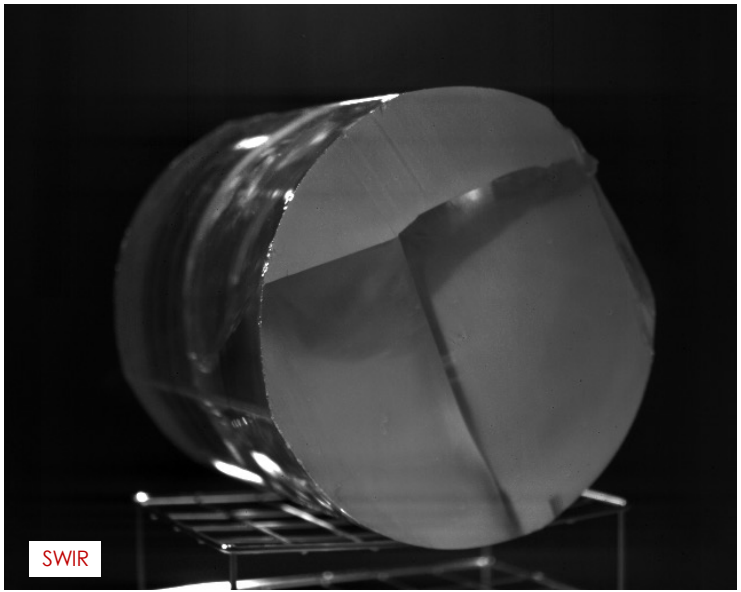
Si-wafer is highly reflective and opaque in VIS light. Thus, objects placed behind the wafer are not visible and only the surface CMOS IC structures can be inspected.



At the longer SWIR wavelengths Si-wafer becomes transparent which allows the examination of the internal and backside structures as well.

Silicon ingot inspection

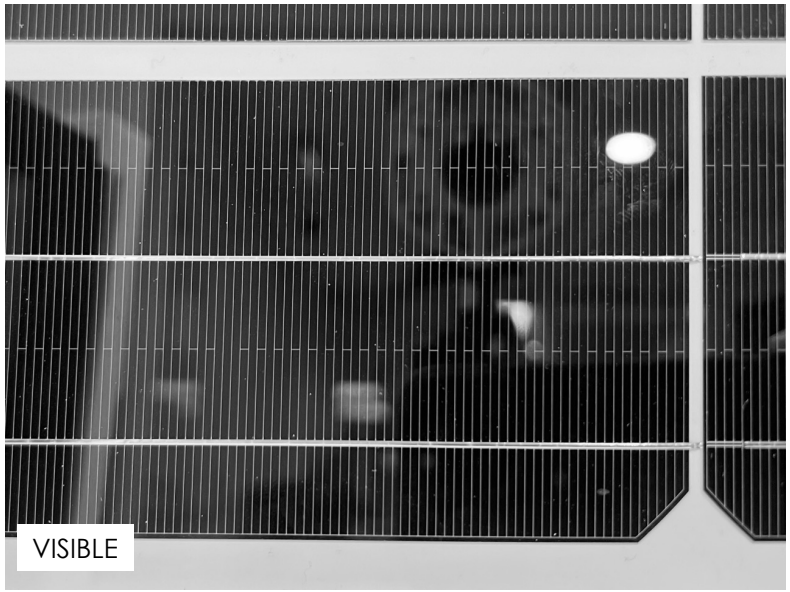




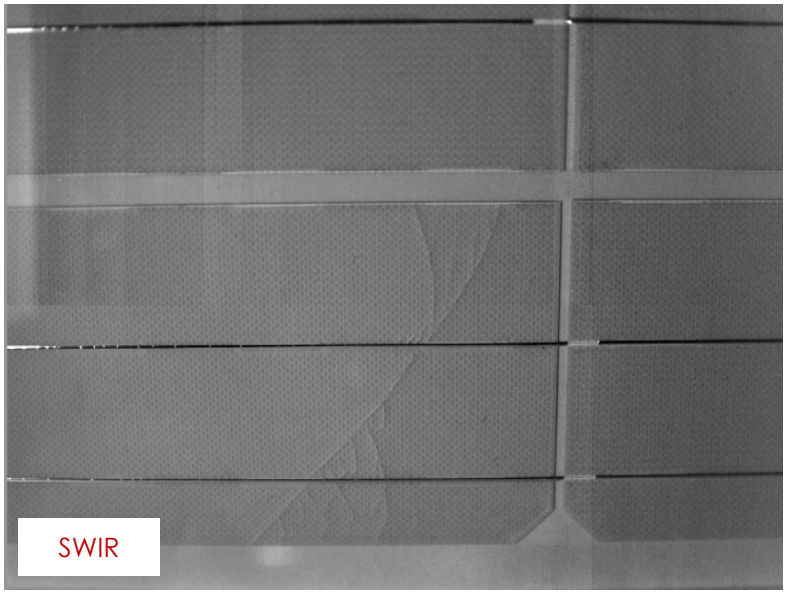
In visible range, only major crack can be seen on surfaces. However in SWIR, every crack inside silicon ingot structure is clearly visible.

The whole silicon ingot becomes transparent in SWIR.

Solar panel inspection



Solar cells can be easily damaged during solar panel production. Under visible light, cracks cannot be detected.



At SWIR wavelengths cracks become visible, and can be detected by Emberion VS20 SWIR camera.

Inspection through packaging

Chowing gums in opaque plastic packaging.
Under SWIR light, plastic packaging starts to show transparency. When wavelength is higher than 1850 nm. Each gum is clearly visible

Inspection through packaging

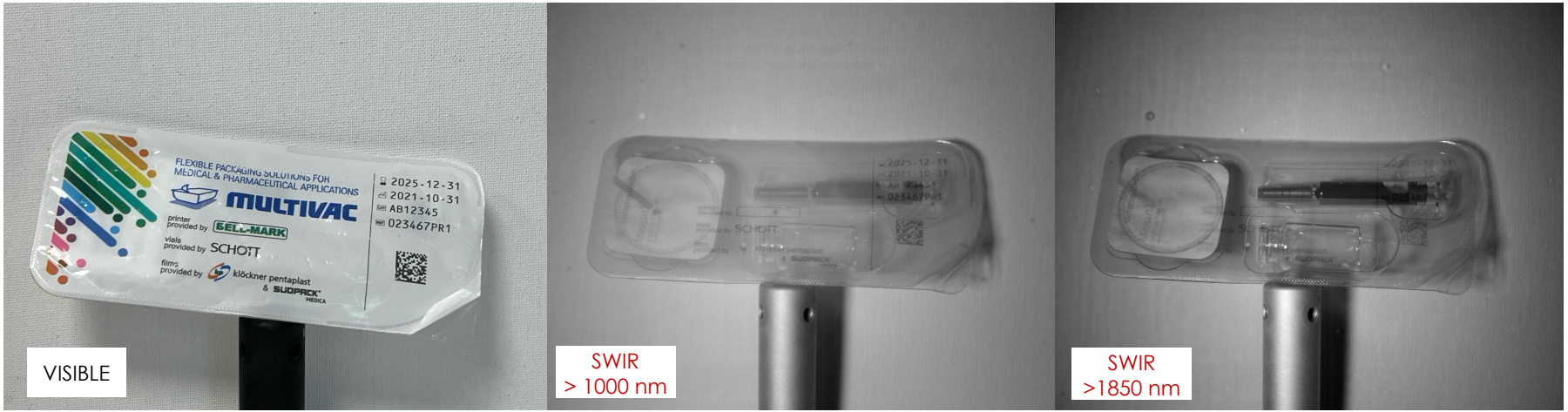
Coffee beans in opaque plastic packaging.
Under SWIR light, plastic packaging starts to show transparency. When wavelength is higher than 1850 nm. Each coffee bean is clearly visible

Seeing through plastic material

Plastic water bottle is fully opaque to visible spectrum light and the content inside cannot be detected.

Plastic water bottle is partially transparent to SWIR light. At wavelength above 1850 nm, the content becomes most apparent. Coffee beans can be seen clearly floating on water surface

Inspection through packaging



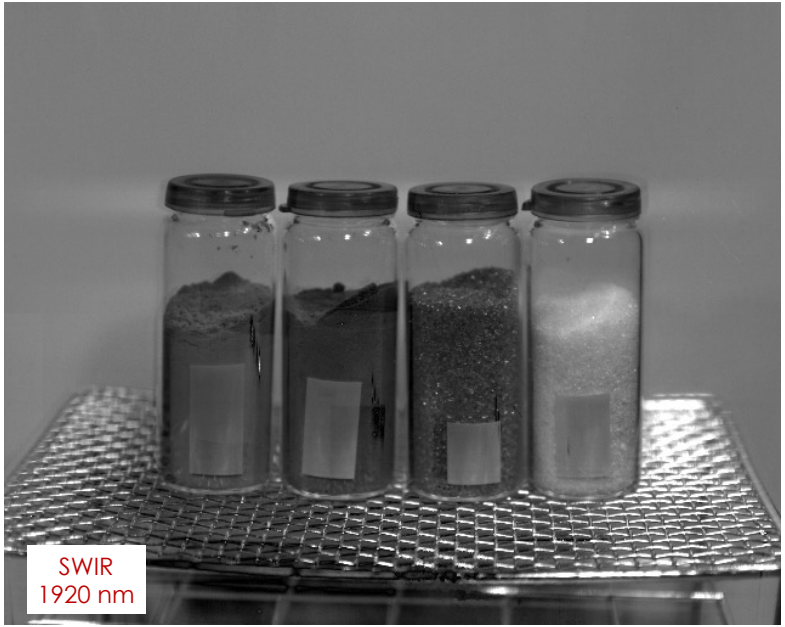
Vials underneath the opaque package are not visible in VIS spectrum.
In SWIR spectrum above 1000 nm, plastic film for packaging starts to become transparent. Best transparency and contrast appears at wavelengths above 1850 nm. Air bubble in the vial is clearly visible.

Inspection through paper label

Vials with paper wrapping 3 times. Paper becomes translucent at specific SWIR wavelengths. This is important for measurements to liquid levels through paper using correct light conditions.

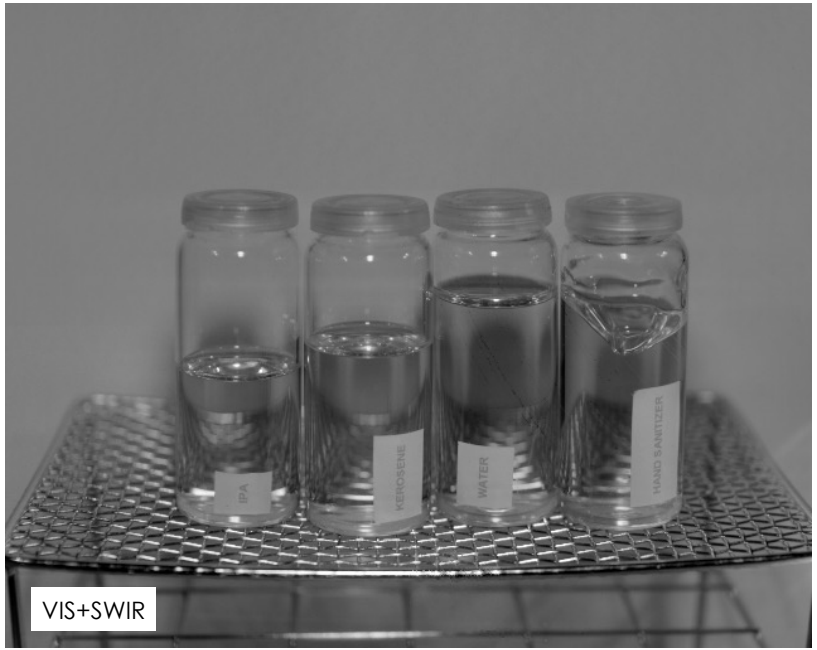
Powder identification

Powder types from left to right: Potato starch, baking soda, sugar, table salt.

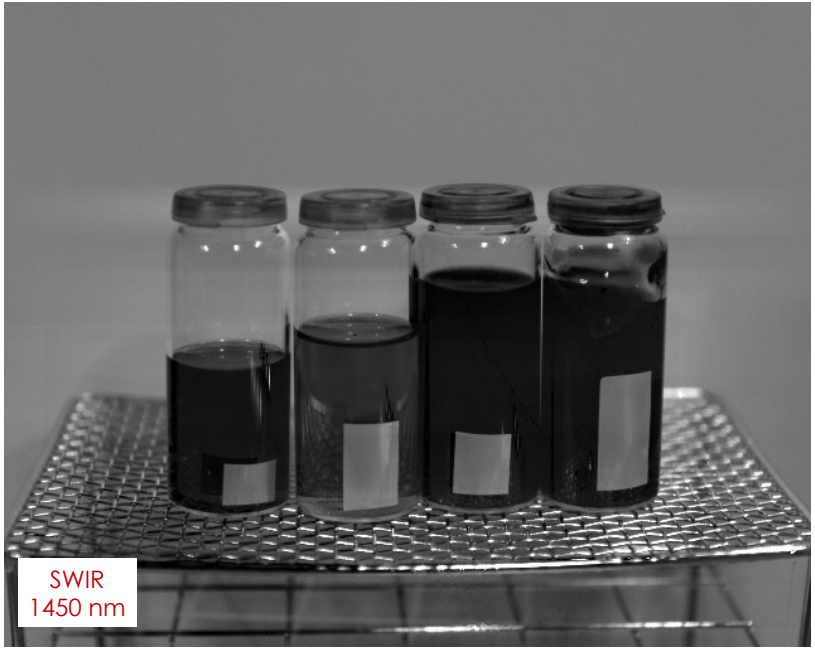


Different contrast levels are observed at SWIR wavelength allowing differentiation of the powder / granule types.

Transparent liquids analysis

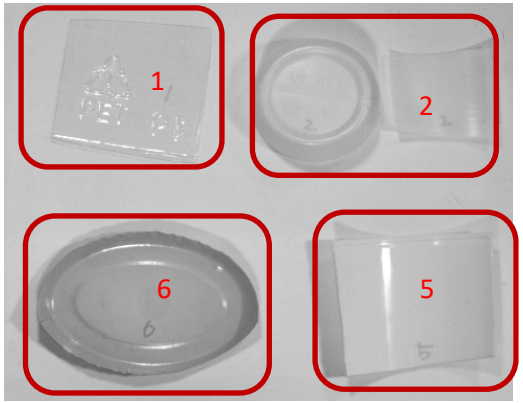


Kerosene, hand sanitizer gel, IPA and water samples all appear colourless and transparent.



Samples containing water and alcohol appear darker than kerosene and oil. Also, the high viscosity of the gel is very prominent in SWIR image.

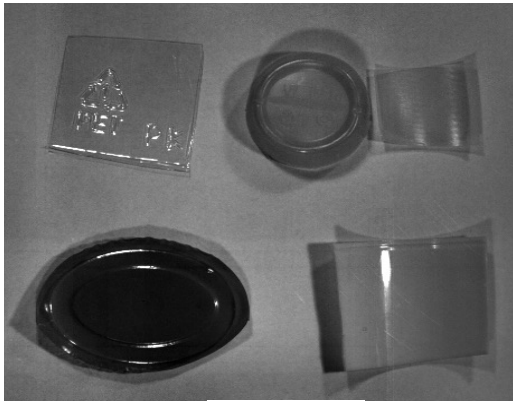
Plastic separation



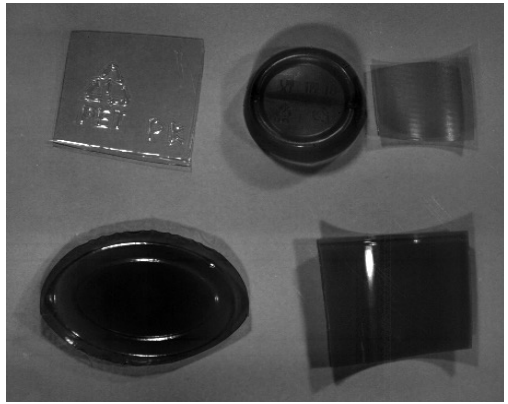
VIS 550nm

Sample type 1 - PET
Sample type 2 - LDPE
Sample type 5 - PP
Sample type 2 - PS

Plastic types have absorption peaks at different wavelengths as the molecules absorb the infrared energy thereby creating stronger and differential contrast levels. The images taken with the Emberion VS20 show that LDPE (2) is absorbing extended SWIR 1920 nm much more prominently compared to 1550 nm and visible at 550 nm. Machine Learning/ AI classification can be used to differentiate the plastics types during optical sorting processes e.g. plastic recycling.



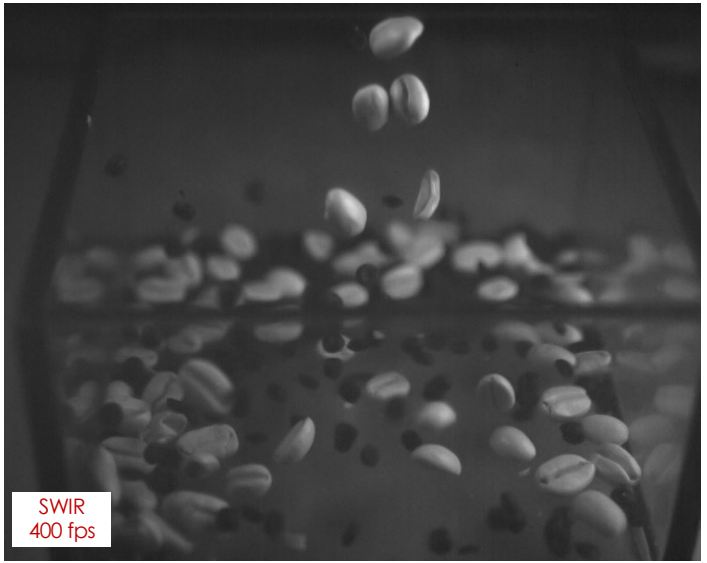
1550nm



1920nm

Foreign object detection during free fall

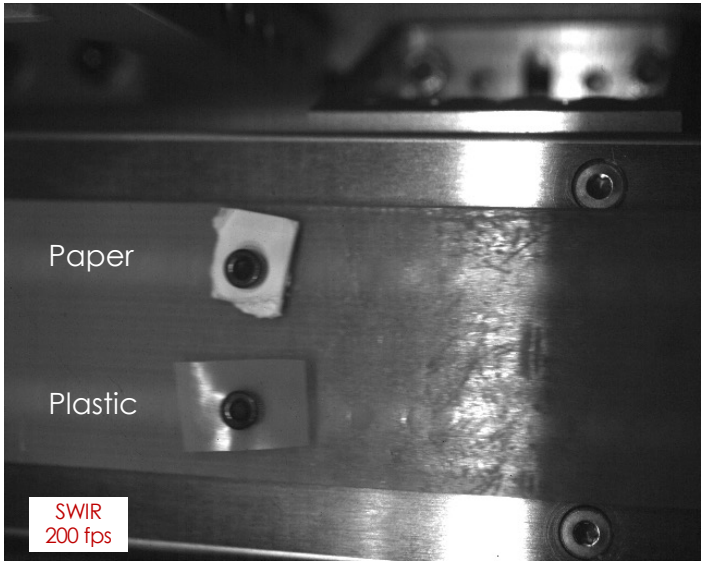
Coffee beans and foreign objects appear very similar in visible light. Such level of contrast makes sorting difficult



However, with SWIR light Emberion VS20 camera is able to differentiate materials by contrast. Running at 400 fps is fully capable for optical sorting during free fall

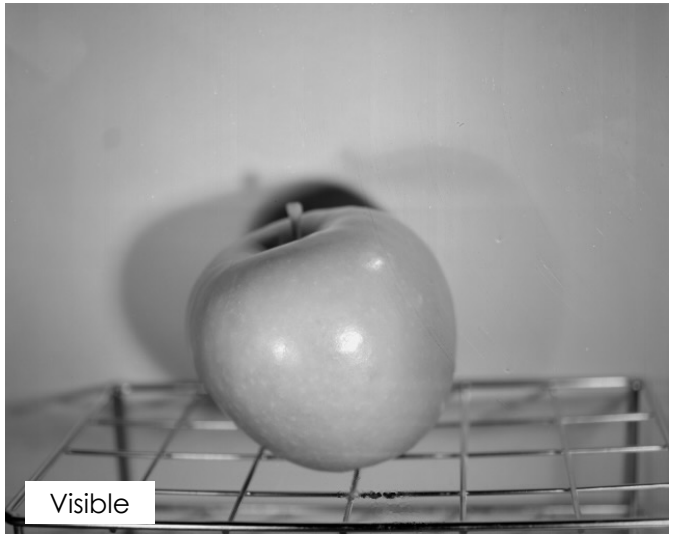
Sorting on conveyor belt

White plastic and paper samples are fixed on conveyor belt, which operates at 1 m/s. With such speed, standard iPhone image can not capture clear image on the belt



With SWIR light Emberion VS20 camera is capable for optical sorting where conveyor belt runs at certain speed

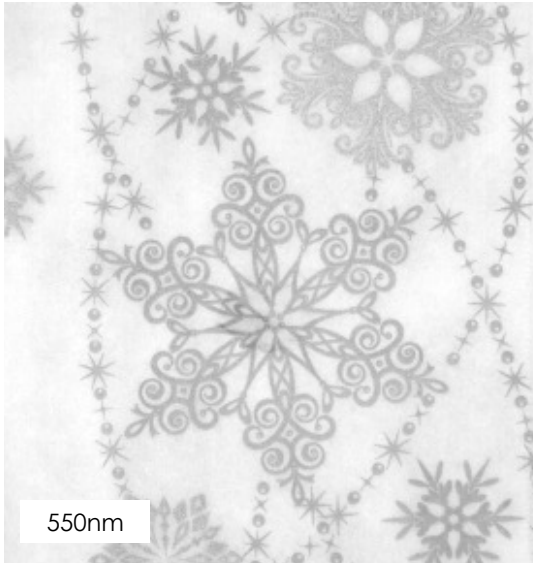
Fruit bruising detection

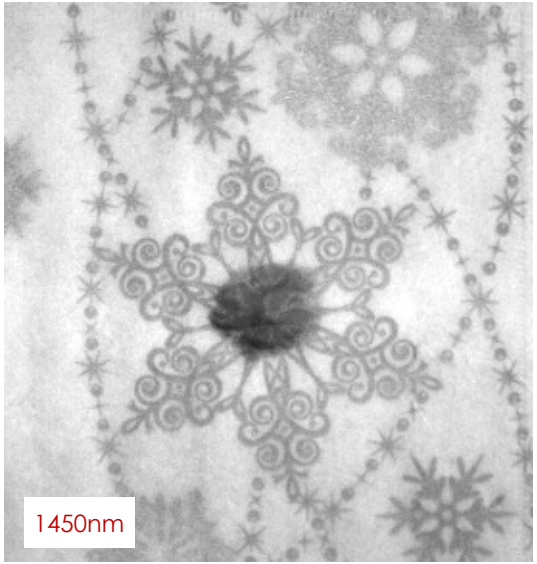


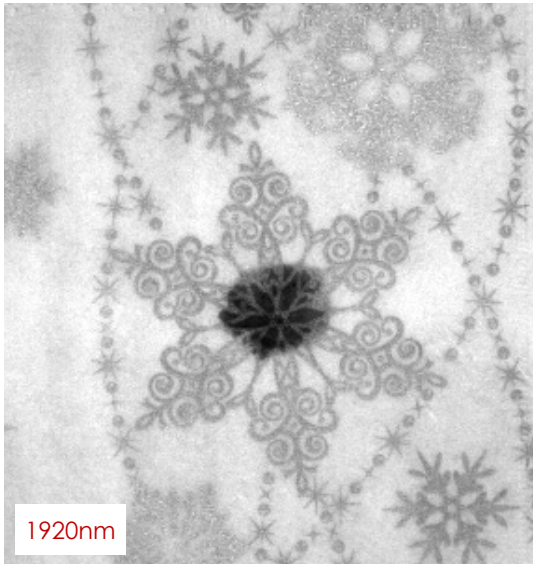
Visible spectrum image does not show any signs of internal bruising of the pear caused by rough handling.

Bruising changes the water density and water distribution in the fruit tissue. Due to the IR light absorption peaks of water around 1450 nm and the bruising is clearly visible.

Moisture detection







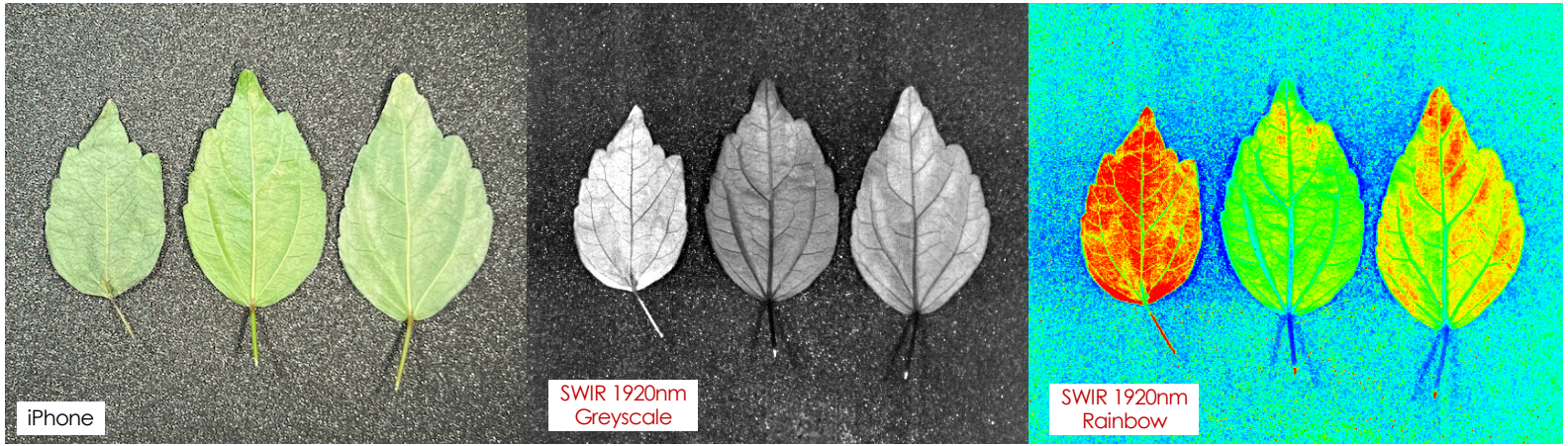
Emberion VS20 has been used to detect water at specific wavelengths using narrowband pass filters. Water absorption peak shows highest contrast at 1920nm and decreasing contrast levels at 1450nm and at visible wavelength it is almost transparent. This process enables contrast differentiation and improve on false defect count.

Moisture detection

Damp coffee beans can not be distinguished from dry ones in the visible range. Above image taken under same lighting condition
- Left: Damp beans with humidity inside
- Right: Fresh dry beans

Under 1920 nm filter, any object with water content appears darker due to strong water absorption peak.
As a result, left pile of damp coffee beans can be simply separated from the dry ones on the right.

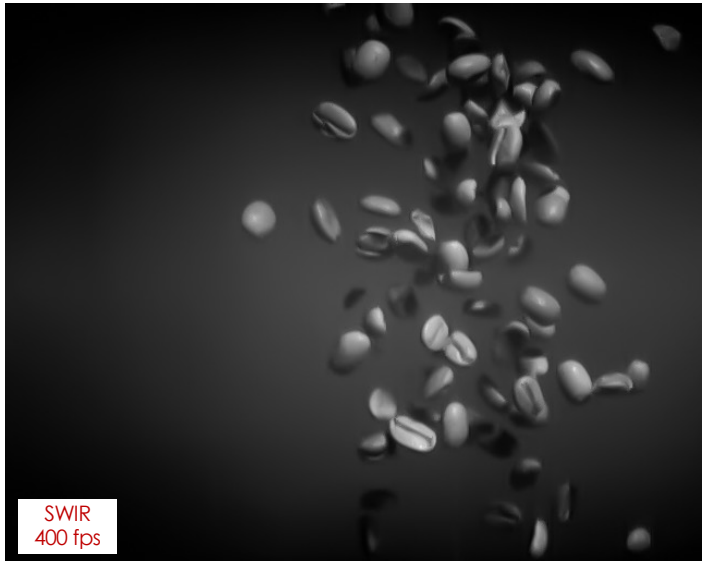
Water in leaves

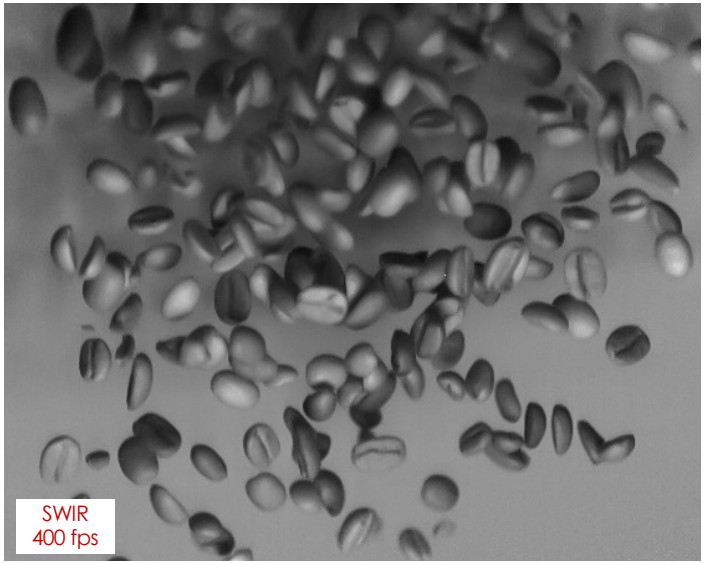


Leaves from left to right
- Picked previous day
- Fresh leaf from healthy plant
- Leaf from plant not watered for 48 hours

Different levels of water content in leaves can be effortlessly identified, using 1920nm Bandpass filter.

Moisture detection during free fall





Wet coffee beans appear darker than fresh ones at 1920 nm, which makes them easy to be detected even during free fall.

Outdoor imaging - HDR advantage

A wide-spectrum VIS-SWIR image resembles a VIS image but there are some prominent dissimilarities in the contrast differences, e.g. tree leaves appear much lighter IR than in VIS light.

The non-linear response characteristic and the wider spectral sensitivity range of Emberion cQD sensor offer a wider dynamic range, see the contrast differences in the clouds, balconies and car windows.

Target at 1.2 km with zoom lens

Chimney at 1.2 km away
Weather Cloudy
Location Espoo Finland

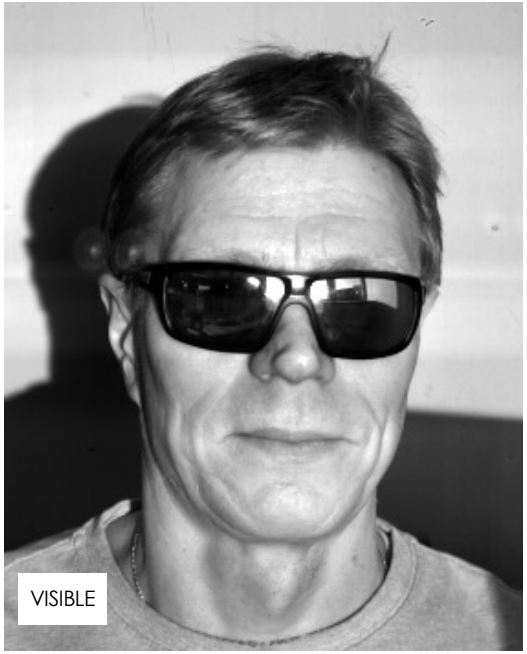
Target at 1.2 km with zoom lens

VIS – SWIR
400 – 2000 nm

SWIR
1000 – 2000 nm

SWIR
1540 – 1560 nm

See though sunglasses - face recognition



Eyes are barely visible behind the sunglasses which makes face recognition very difficult.

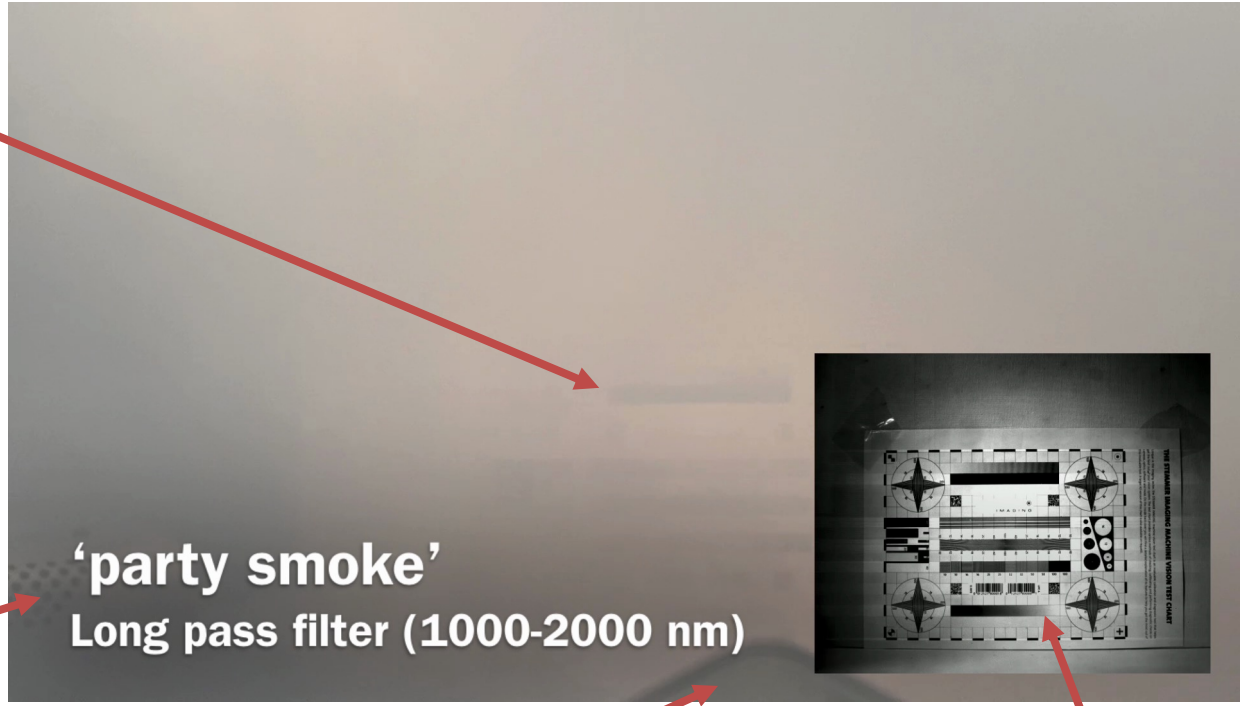
Hair colour appearing shiny white with skin colour looking darker compared to VIS light image. Black plastic sunglasses are fully transparent allowing easier detection of facial recognition.

See though smoke – adverse condition

Image on the left showing visible smoke from campfire blocking the scene. The same image can be seen through the smoke using Emberion VS20 SWIR camera using 1550nm filter. **SWIR penetrates through smoke particles allowing adverse condition surveillance** (defence, night vision, firefighting, automotive)

See though smoke

Test target is barely visible in the video image frame captured by iPhone 11 Pro mobile phone.

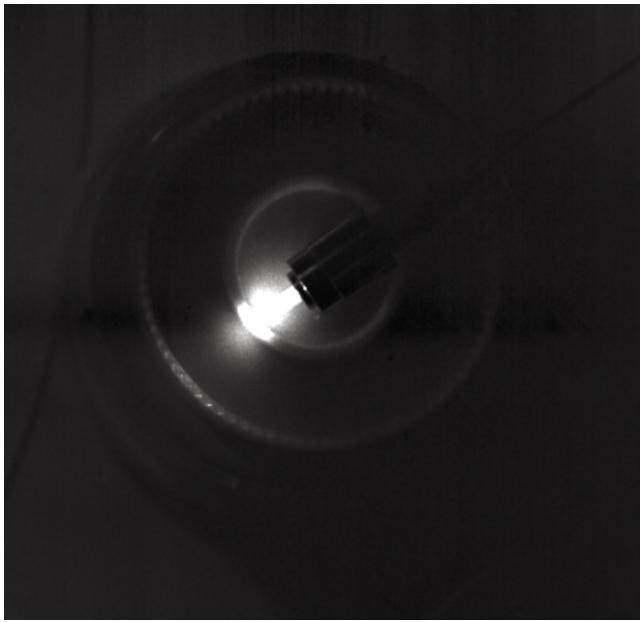


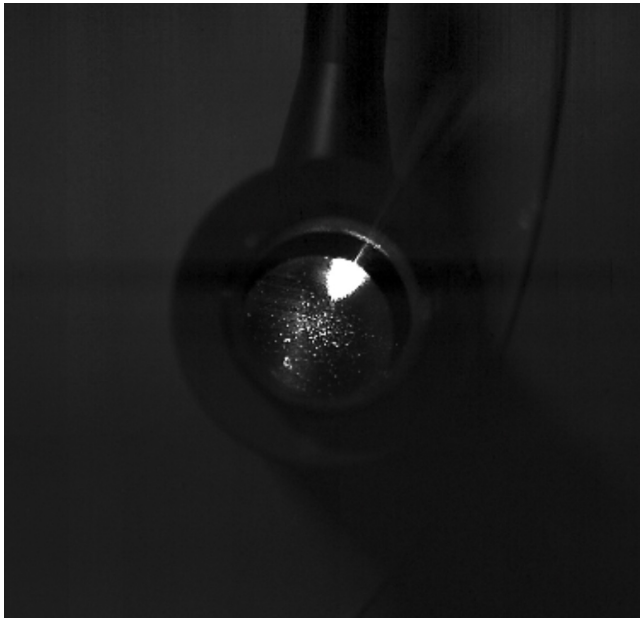
Smoke generator

Emberion VS20 camera

Test target image captured in office light and with IR pass filter by Emberion VS20 camera at the same time moment as the mobile phone image.

1550nm laser detection



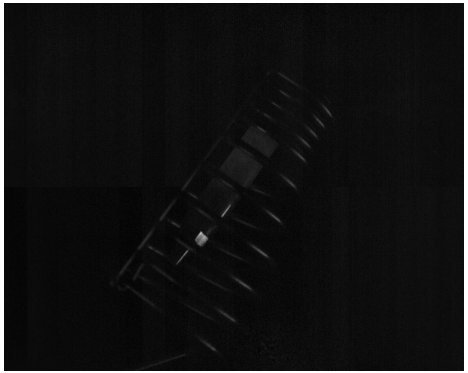


Laser emitter (1550nm) SWIR images shot by Emberion VS20. Spectral response of the camera is up to 2000nm.

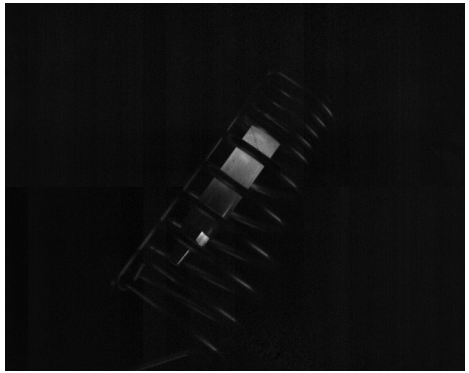
Camouflage detection

Camouflage detected behind trees
Military uniform has NIR coating, however in SWIR range coating protection is still vulnerable

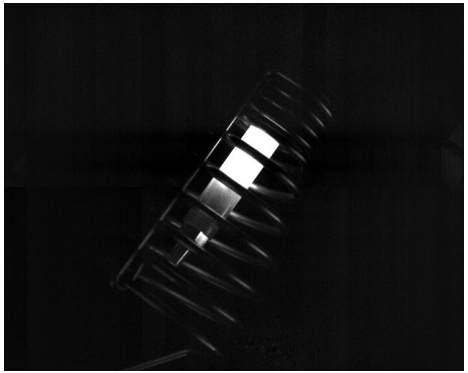
Heat detection



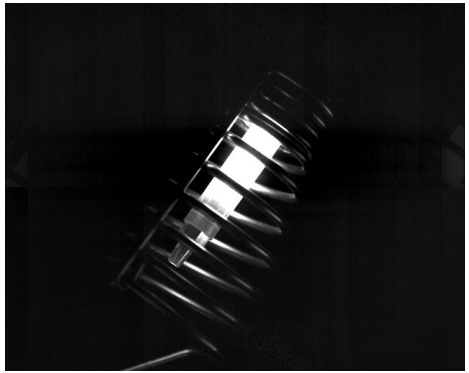
Soldering iron at 200 degree C



Soldering iron at 300 degree C



Soldering iron at 400 degree C



Soldering iron at 500 degree C

Emberion VS20 can be also used for temperature identification. Due to the high dynamic range of the camera bright soldering iron does not saturate the sensor and wide range of temperature profiles can be observed in the same scene allowing broad temperature analysis for various applications.

See images above showcasing hot soldering iron pictures taken by Emberion VIS-SWIR camera from 200°C to 500°C degree.

For accurate temperature profile measurements, please contact Emberion for custom camera calibration.