



1 With a conventional camera, the potted electronics in an electronic key tag are hardly recognizable (left). A SWIR camera makes the chip easily visible (right).

2 The SWIR («shortwave infrared») spectrum is directly adjacent to the visible spectral region.

## SWIR-INSPECTION IMAGING INLINE ANALYTICS BEYOND THE VISIBLE SPECTRAL RANGE

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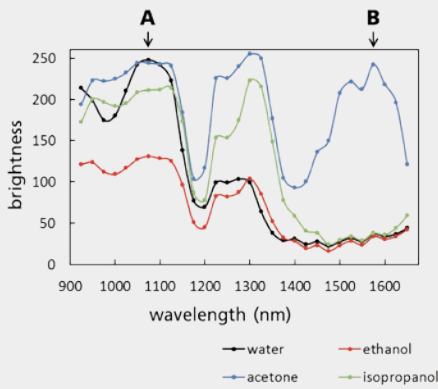
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#### Invisible material contrasts

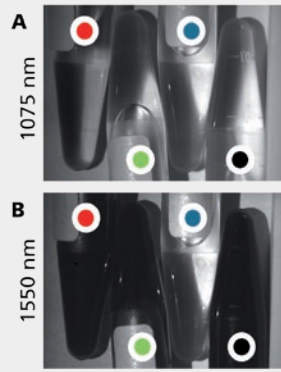
Even the human eye is excellent at detecting different colors and light intensities – but only in the visible wavelength band between approximately 400 and 800 nm. However, optical contrasts are not solely restricted to the visible spectral range. Many substances show contrast differences which are valuable for analytics in the shortwave infrared region between 900 and 1,700 nm (Fig. 2). But neither the eye nor conventional cameras are sensitive to this spectral range. What are called SWIR cameras with InGaAs sensor solve the problem. They provide excellent images in the shortwave infrared range (SWIR). They can be used to examine workpieces and material compositions which do not show contrast for conventional cameras.

#### Preliminary inspections and system integration

Fraunhofer IPM has the expertise to solve challenging optical measuring tasks – starting with a feasibility study through to supply and servicing of individual inline inspection systems for production control. In addition to standard methods, we also supply specially developed measuring stations for examining and characterizing sample components. For investigating customer components we set up a test stand with spectrally tunable light source and camera for the SWIR region covering the wavelength band between 900 and 1,700 nm. The results can be used to determine optimal configurations for inline inspection tasks and to develop algorithms for fast, automated defect detection.



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Moreover, Fraunhofer IPM has many years of experience in developing and integrating inspection equipment for production control which operates reliably even under harsh ambient conditions. This allows us to offer individual, turn-key, all-in solutions, all from one single source.

### Surprising material properties

The spectral dependence of absorption and scattering properties means that many non-transparent materials appear transparent to a SWIR camera. Such materials include certain plastics and also silicon.

This infrared transparency can be utilized to make visible concealed elements, such as potted electronic circuitry (Fig. 1). In silicon, even microscopic cracks become recognizable as distinct shadows.

In addition, reduced light scatter in the infrared range allows process monitoring in environments containing steam or smoke, for instance. Conversely, many transparent substances show characteristic absorption bands in the infrared spectrum which make it possible to differentiate such materials. Examples of these include transparent plastics and solvents. Water in particular shows strong absorption of

light of around 1,500 nm (Fig. 3). Amongst other things, this property can be used to measure moisture. Other applications relate to examining security features, e. g. by inspecting printing inks in the infrared spectrum.

SWIR cameras are insensitive to thermal radiation at room temperature. This offers a substantial advantage over typical infrared cameras which are sensitive at very large wavelengths beyond 8 μm. However, SWIR cameras can also be used for temperature measurement and thus, for example, for process monitoring at temperatures above approximately 140 °C.

### Illumination characteristics

- Individually designed LED illumination
- Identification of suitable wavelength(s) by means of continuously tunable laboratory light source
- Eye-safe design

### Camera characteristics

Spectral range	900 – 1,700 nm
Sensor type	thermoelectrically cooled InGaAs sensor
Standard resolution	640 × 512 pixels
Exposure times	> 30 ms

All specifications and features are subject to modification without notice.

3 Various solvents, which appear to have the same transparency to the human eye, have different absorption bands in the SWIR spectrum. This means that water, for instance, unlike acetone, appears black at 1,550 nm.

4 An industry-standard SWIR camera combined with various illumination options allows extensive examinations on the basis of which inspection systems for special tasks in production can be optimally designed.