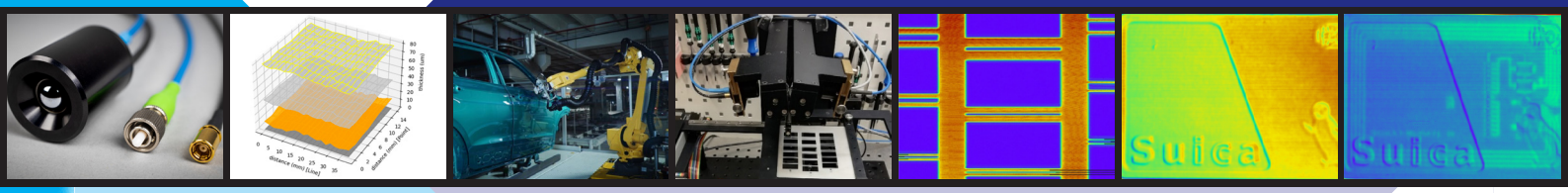


Terahertz technologies for specific applications

There are four main commercial terahertz (THz) technologies suitable for industrial use.

Time-domain spectroscopy

Time-domain spectroscopy (TDS) uses a pulsed THz signal activated by a laser.

The transmitter and receiver are fibre-coupled.

Achievable specifications (under optimal conditions):

- Bandwidth: 0.1-6 THz
- Frequency resolution:
  - 0.5 GHz using delay
  - 1.5 GHz using ECOPS
  - 100 MHz using ASOPS
- Spatial resolution: 250-1000 µm, depending on frequency
- Depth resolution: 5-10 µm

Frequency-modulated continuous wave

Frequency-modulated continuous wave (FMCW) uses a THz signal activated by a laser.

The transmitter and receiver are fibre-coupled.

Achievable specifications (under optimal conditions):

- Bandwidth: 0.1-4 THz
- Frequency resolution: 1 GHz
- Spatial resolution: 500-1000 µm, depending on frequency
- Depth resolution: 20 µm

Electronic FMCW operates at a fixed frequency up to 0.6 THz.

Continuous wave photonic-based frequency domain

Continuous wave photonic-based frequency domain (CW) uses a THz signal activated by a laser.

The transmitter and receiver are fibre-coupled.

Achievable specifications (under optimal conditions):

- Bandwidth: 0.05-3.2 THz
- Frequency resolution: 10 MHz
- Spatial resolution: 500-1000 µm, depending on frequency
- Depth resolution: N/A

Vector network analysis

Vector network analysis (VNA) uses a THz signal generated electronically.

The transmitter and receiver are waveguide-coupled in a rigid configuration.

Achievable specifications (under optimal conditions):

- Bandwidth: 0.01-1.2 THz
  - Note: Several sets of frequency extenders and waveguides are required to access the bandwidth.
  - Measurements are performed in waveguide-defined sub-octave bands.
- Frequency resolution: 1 MHz
- Spatial resolution: 2-5 mm, depending on frequency
- Depth resolution: N/A

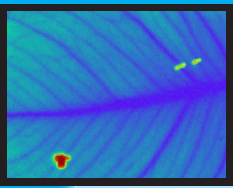
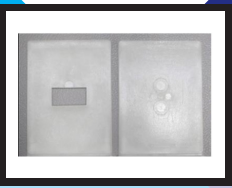
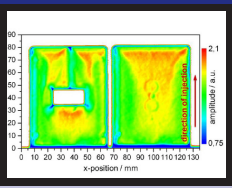
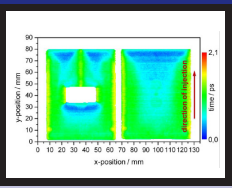
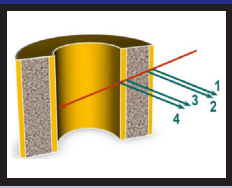
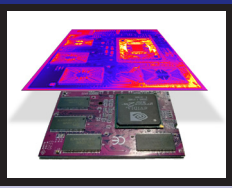
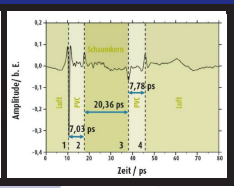
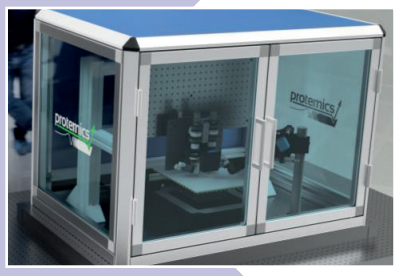
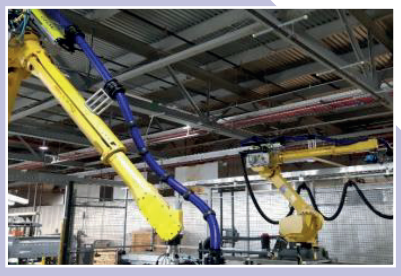
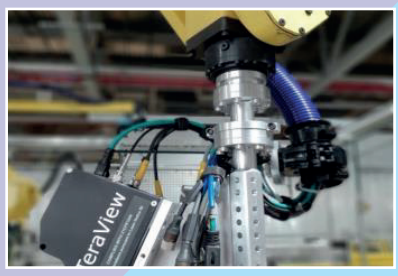








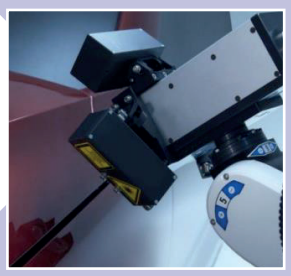
Table 1. Terahertz technologies suitable for various applications

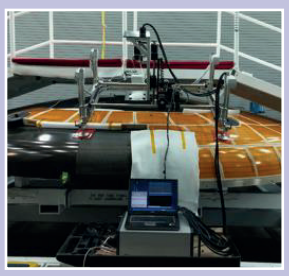
Application	THz technology
Coatings monitoring and inspection ▶ Thickness of every layer in mono- and multilayer coatings ▶ Coating thickness uniformity ▶ Coating porosity ▶ Layer adhesion/delamination	TDS FMCW
Conductivity and other electrical properties of thin films	TDS FMCW CW VNA
Corrosion/damage under coatings	TDS FMCW CW
Material inspection ▶ Complex permittivity ▶ Substance identification ▶ Porosity ▶ Moisture content ▶ Presence of contaminants	TDS FMCW CW VNA
Imaging internal structures ▶ Layer thickness/uniformity ▶ Defects ▶ Voids ▶ Cracks and faults ▶ Debonding ▶ Delamination	TDS FMCW
Trace gas sensing	CW VNA
Moisture content	TDS FMCW CW VNA











BINDT
THE BRITISH INSTITUTE OF NON-DESTRUCTIVE TESTING

Prepared by the Terahertz User Group
of the British Institute of Non-Destructive Testing
Midsummer House, Riverside Way, Bedford Road, Northampton NN1 5NX, UK
Tel: +44 (0)1604 438300 | Email: info@bindt.org | Web: www.bindt.org

...engineering safety, integrity & reliability

ICNDT