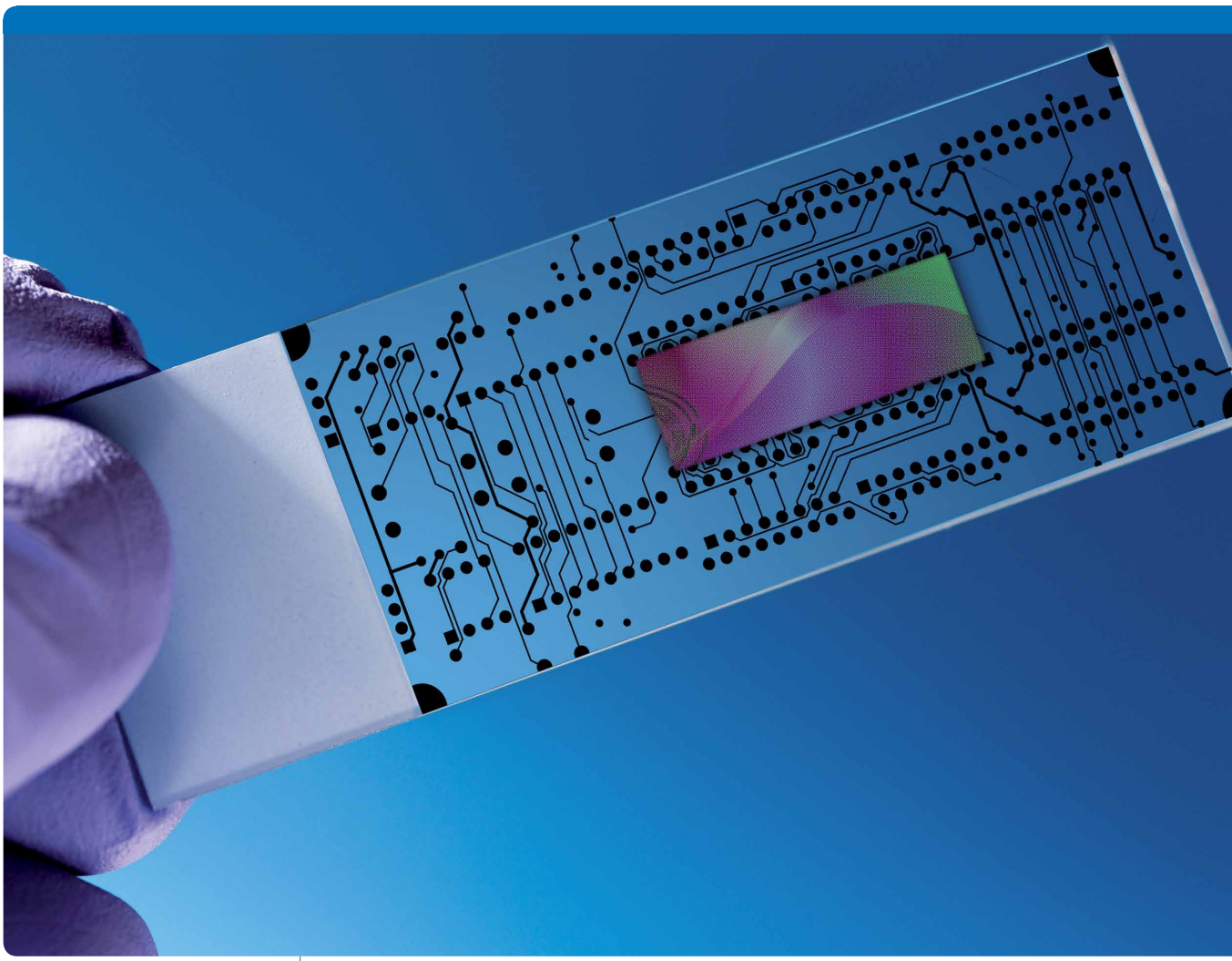


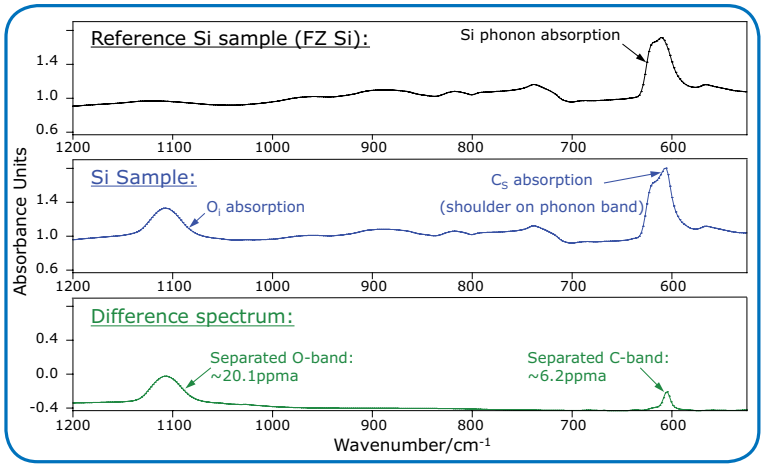
FT-IR

- Semiconductor Applications

Room Temperature Carbon and Oxygen Quantification in Silicon

FT-IR analysis of Carbon and Oxygen in Silicon is fast, sensitive, destruction free and therefore a widely accepted method of Si quality control. Bruker has decades of experience in this field and based on the *VERTEX series* we offer the most powerful and up to date solutions.

- Room temperature quantification of substitutional Carbon in Si according to ASTM/SEMI MF1391
- Room temperature quantification of interstitial Oxygen in Si according to ASTM/SEMI MF1188
- Achievable detection limits <400ppba
- Recommended Sample properties: thickness 0.5-2.5 mm (ideal ~1.5 mm), double-sided polished, single crystal or polycrystalline

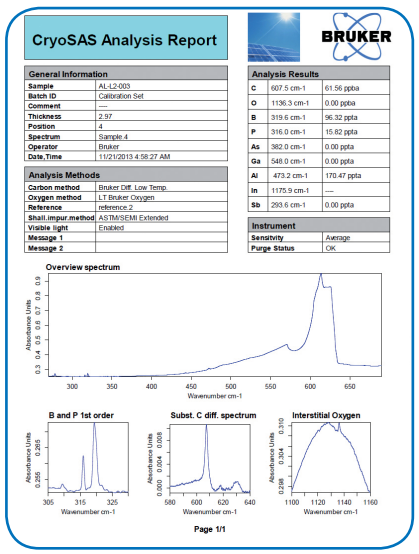


Silicon Analysis

CryoSAS: The ultimate Analyzer for high Sensitivity Silicon Quality Control

CryoSAS is a unique low temperature analyzer for high sensitivity QC of solar and electronic grade Silicon. It simultaneously quantifies Carbon, Oxygen and shallow impurities (B, P, As etc.) according to ASTM/SEMI standards, is easy to operate and does not require cryogenic liquids. Compared to e.g. old fashioned wet chemical methods, CryoSAS is much more sensitive, faster and destruction free.

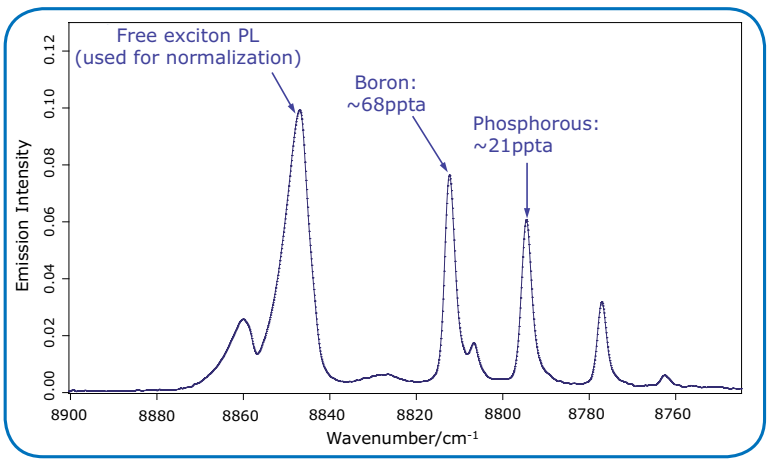
- Quantification of group III & V impurities (B, P, As, Al, Ga, Sb) in single crystal Si down to the low ppta range
- Quantification of substitutional carbon in polysilicon or single crystal Si down to the low ppba range
- Quantification of interstitial oxygen in polysilicon or single crystal Si down to the low ppba range
- Fully automated measurement cycle and data evaluation, including report generation



Low Temperature Photoluminescence for Silicon QC

Low temperature NIR photoluminescence (PL) enables the quantification of shallow impurities (e.g. B, P) in single crystal Silicon, according to ASTM/SEMI MF1389. Combining the unmatched sensitivity of the *VERTEX 80* FT-IR spectrometer and a dedicated Si photoluminescence module with cryostat, detection limits less than 1ppta are achievable.

- B, P and Al quantification in single crystal Silicon according to ASTM/SEMI MF1389
- TCS (Trichlorosilane) quality control by PL of epitaxial Si layers deposited from TCS via CVD
- Various options such as cryostat automation, dedicated software for Si QC by photoluminescence, calibration samples and 2nd additional excitation laser

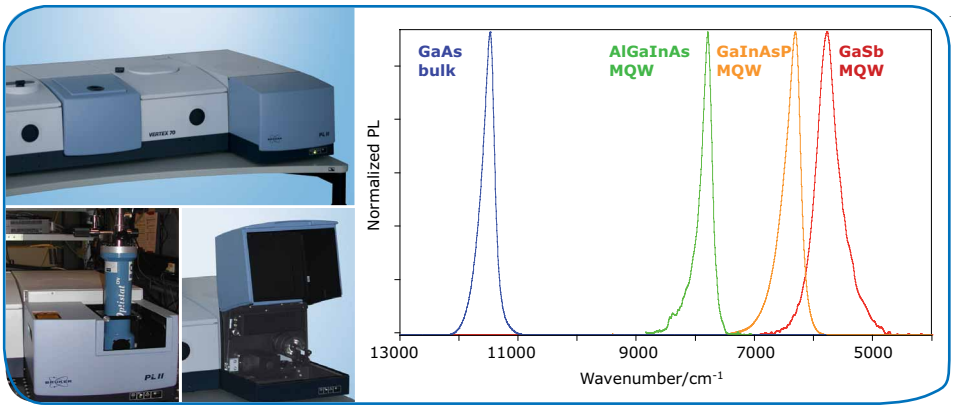


Photoluminescence

Near Infrared Photoluminescence for Research and Development

Photoluminescence is an important tool for research and development in the field of semiconductors and optoelectronics. In the infrared spectral range FT-IR spectroscopy has a significantly higher sensitivity than dispersive techniques and with the *PLII module* adapted to the *VERTEX series* Bruker offers the most flexible and powerful solution on the market.

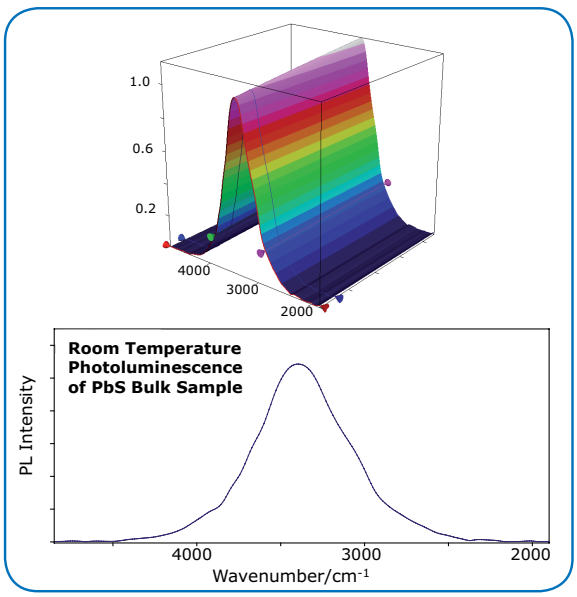
- Infrared PL of bulk samples, quantum wells/dots etc. with utmost sensitivity in the range above approx. 4000 cm^{-1} (< 2.5 µm)
- Optional 2nd internal excitation laser or operation with external laser
- Dedicated accessories such as e.g. mapping stage, video objective and cryostat adaption

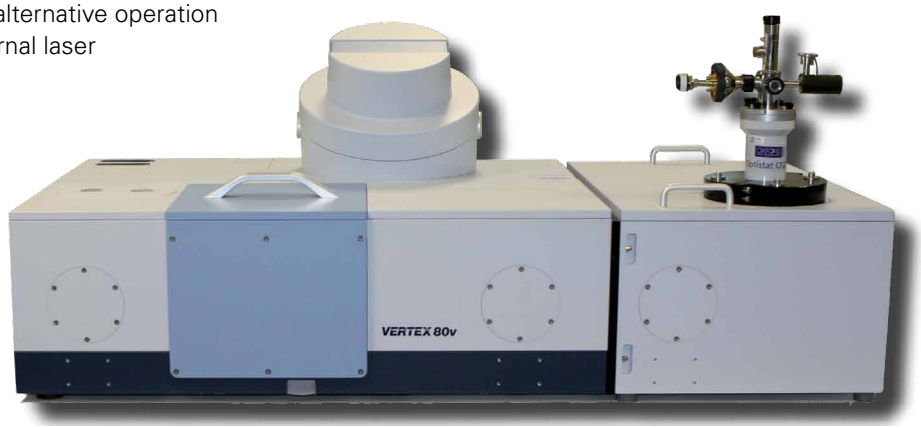


Mid Infrared Vacuum Photoluminescence for Research and Development

In the mid infrared spectral range below 4000 cm^{-1} (>2.5µm, respectively) PL spectroscopy is a particularly challenging task due to atmospheric absorption and thermal background radiation. The *VERTEX 80v* in conjunction with a dedicated *vacuum PL module* is the ideal solution to overcome these effects and to measure PL spectra down to 1000 cm^{-1} (10µm) and even beyond.

- Vacuum FT-IR system for mid infrared PL of bulk samples, quantum wells/dots etc. without atmospheric interferences, extensible to NIR PL
- Modulation techniques with highest step-scan performance to suppress thermal background radiation
- Additional automated beam paths for photo modulated reflectance & transmittance
- Optional adaption of cryostat and lasers or alternative operation with external laser



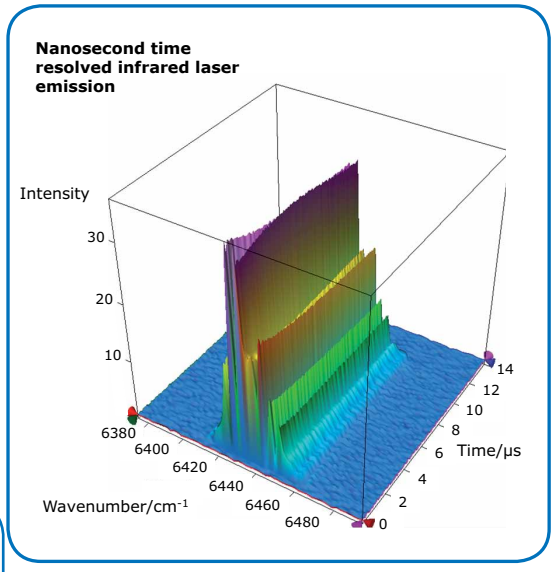


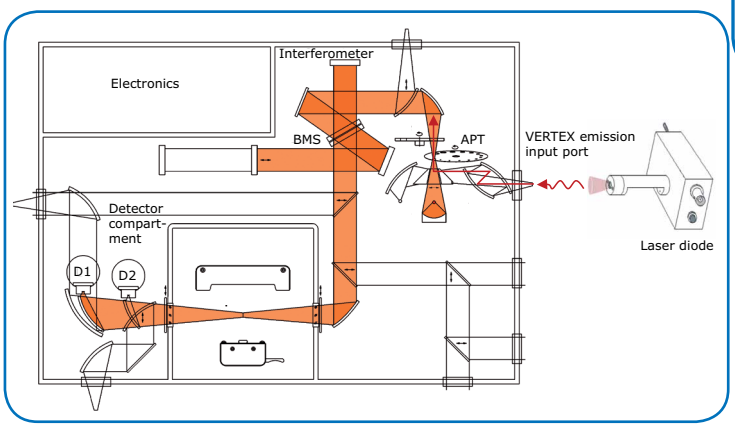
Optoelectronics

Laser and LED Emission, Electroluminescence

In particular in the infrared spectral range FT-IR spectroscopy is the ideal tool to analyze the emission of lasers, LEDs or electroluminescence. Highest spectral resolution allows completely resolving the laser modes and in the mid infrared *VERTEX* vacuum spectrometers allow to suppress artifacts of atmospheric absorption such as water vapor.

- Characterization of cw and pulsed infrared lasers and LEDs with highest wavenumber (wavelength) accuracy
- Available with unmatched spectral resolution up to 0.06 cm^{-1}
- Time resolved emission measurements with time resolution down to the low ns range

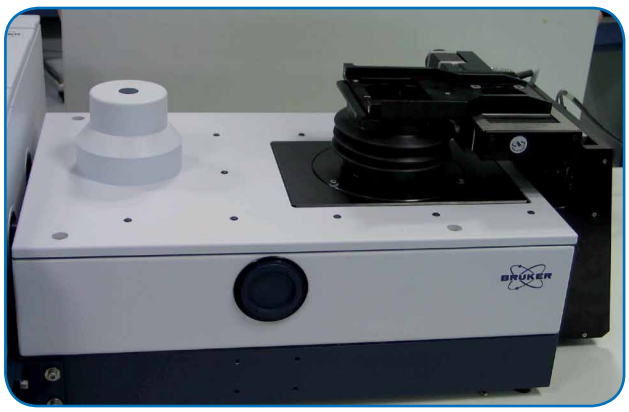


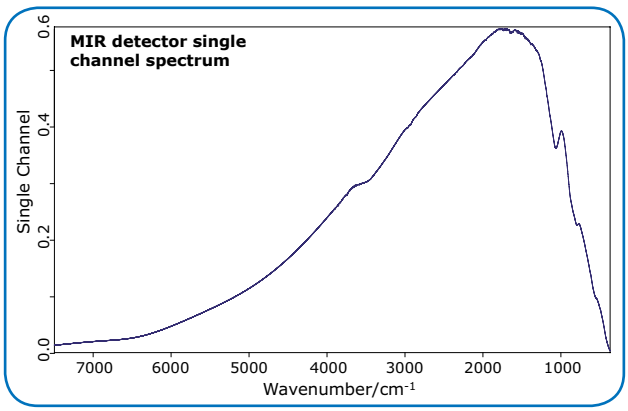


Detector Testing and Characterization

The Vertex series allows testing and characterizing self-developed infrared detectors. Single element detectors may be directly adapted to one of the five optional *VERTEX* beam output ports, using external optics. For characterization of FPA (focal plane array) detectors dedicated VERTEX *modules* for down looking or side looking detectors are available.

- Characterization of single element detectors
- Characterization of side looking or down looking FPA detectors
- Various VERTEX beam output ports for adaption and dedicated modules for FPA detectors



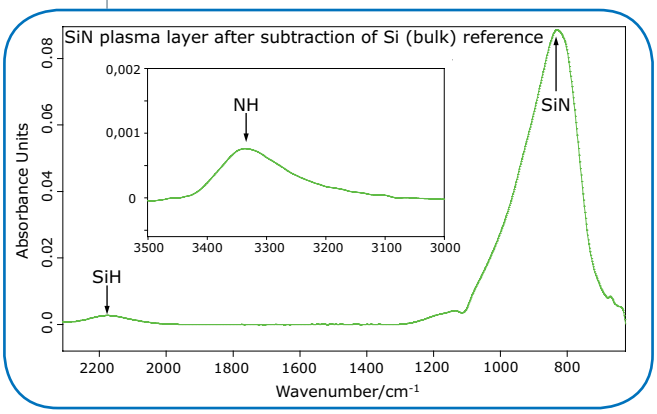


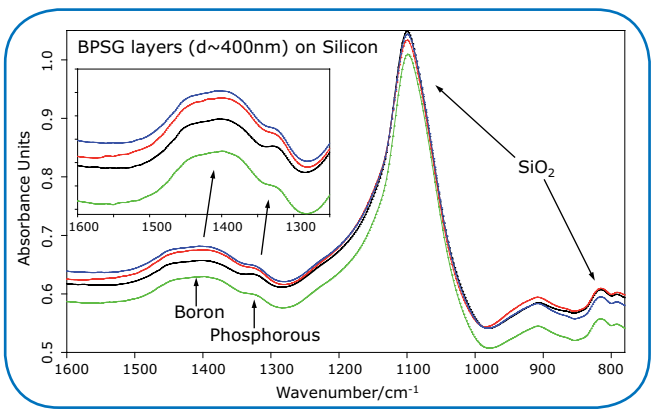
Layer Analysis

Passivation Layer Analysis

Passivation layers on semiconductors play an important role and serve e.g. as protection, electric isolation or anti reflectance layer. *VERTEX series* FT-IR spectrometers are the ideal tools for the fast, sensitive and non-destructive analysis of such passivation layers.

- Quantification of Boron and Phosphorous Phosphosilicate glass (PSG) and Borophosphosilicate glass (BPSG)
- Analysis of SiN plasma layers and Silicon Oxide based passivation layers
- Investigation of ultra-low k layers

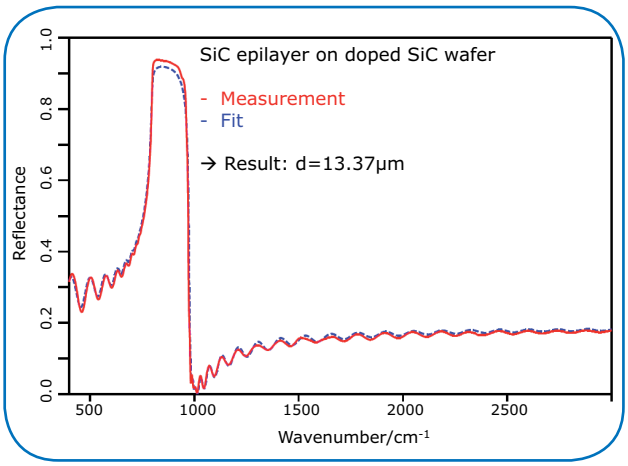




Layer Thickness Analysis

VERTEX series FT-IR spectrometers allow determining the layer thickness of semiconductor layer structures with highest accuracy. This application is based on the evaluation of interferences created by the investigated layers and can be applied to layers with a thickness between less than 1micron and up to several mm.

- Layer thickness determination in reflection and transmission geometry
- Dedicated software for modeling and evaluation of complex layer structures available
- Optional combination with wafer mapping accessory for wafer diameters up to 12”

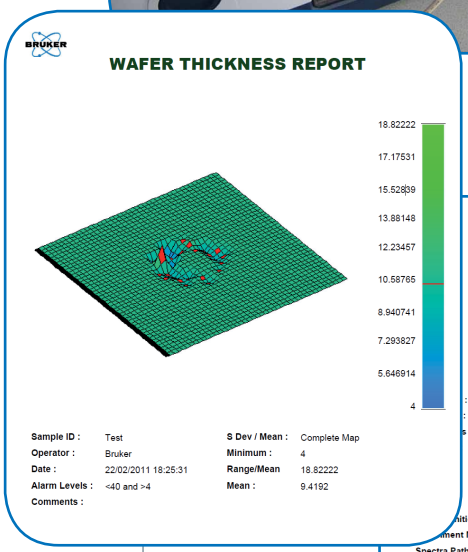


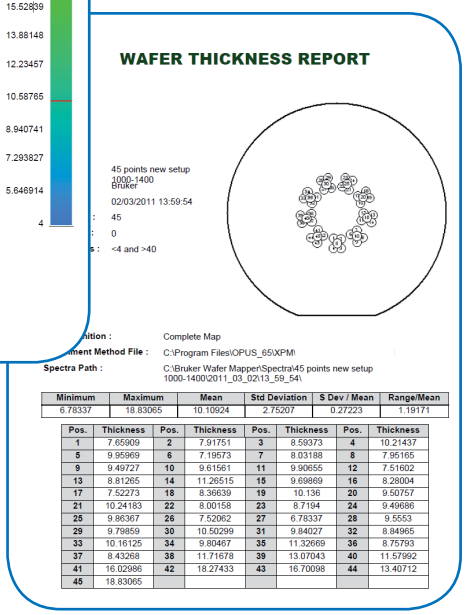
Wafer Mapping / GaAs

Wafer Mapping

VERTEX series purged spectrometers can be equipped with a wafer mapping accessory for wafer diameters up to 12" allowing for the automated acquisition of reflectance or transmittance spectra at different sample positions. Mapping measurements can be combined with various applications such as layer thickness evaluation, quantitative analysis of BPSG layers and many more.

- FT-IR reflectance and transmittance analysis of wafers up to 12" in diameter
- Automatic application of layer thickness methods or quantitative analysis
- Inserts for special wafer shapes available on request





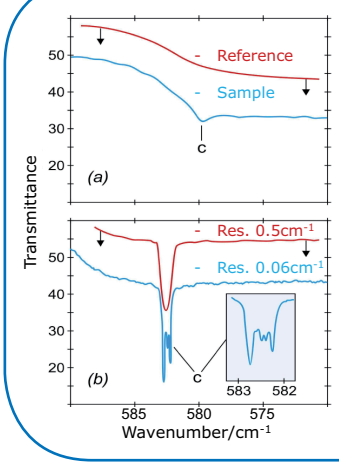
Minimum	Maximum	Mean	Std Deviation	S Dev / Mean	Range/Mean
6.78337	18.83065	10.10924	2.75207	0.27223	1.19171

Pos.	Thickness	Pos.	Thickness	Pos.	Thickness	Pos.	Thickness
1	7.65909	2	7.91751	3	8.59373	4	10.21437
5	9.95969	6	7.19573	7	8.03188	8	7.95165
9	9.49727	10	9.61561	11	9.90655	12	7.51602
13	8.81265	14	11.26515	15	9.69869	16	8.28004
17	7.52273	18	8.36639	19	10.136	20	9.50757
21	10.24183	22	8.00158	23	8.7194	24	9.49686
25	9.86367	26	7.52062	27	6.78337	28	9.5553
29	9.79859	30	10.50299	31	9.84027	32	8.84965
33	10.16125	34	9.80467	35	11.32669	36	8.75793
37	8.43268	38	11.71678	39	13.07043	40	11.57992
41	16.02986	42	18.27433	43	16.70098	44	13.40712
45	18.83065						

Impurity Analysis in GaAs

GaAs is most likely the 2nd most important semiconductor after Silicon. *VERTEX series* FT-IR spectrometers with suitable accessories and optional cryostat allow for highly sensitive impurity analysis in GaAs samples.

- Carbon analysis in GaAs at room temperature and low temperature
- Low temperature analysis of Boron, sensitive to different Boron isotopes



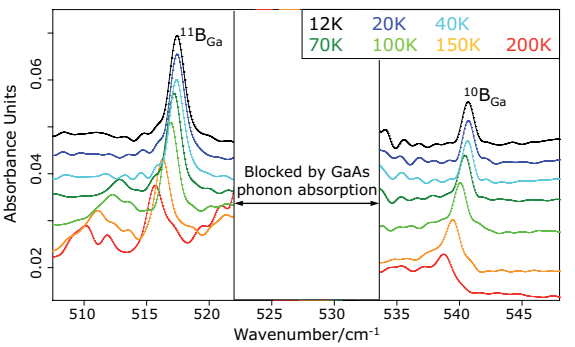
Carbon analysis in GaAs:

Room temperature analysis

For improved sensitivity:

- Low temperature analysis at 77K
- Highest spectral resolution of ~0.06cm^{-1} under vacuum conditions (VERTEX80v)

Low temperature analysis of Boron in GaAs



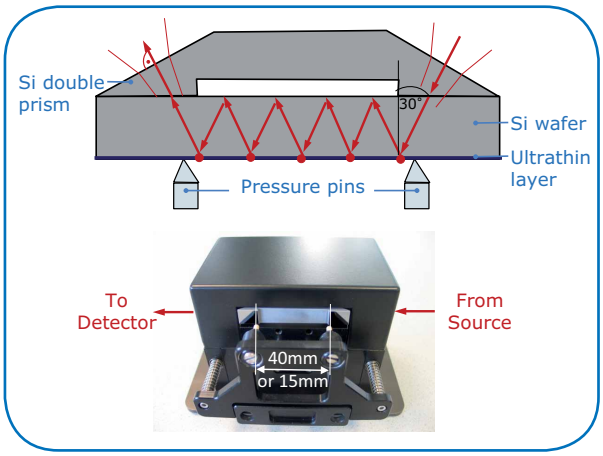
- B-GaAs lattice vibrational mode: sensitive to different Boron isotopes
- Detection limit with ideal setup: ~1*10^{15}/cm^3
  → VERTEX vacuum spectrometer

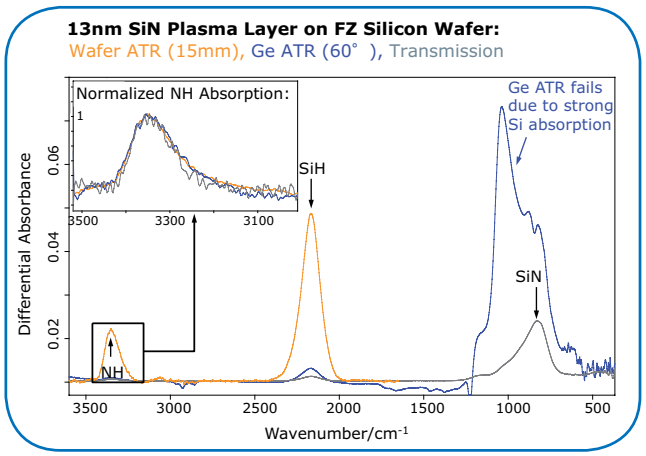
Additional Research Applications

Wafer ATR: high Sensitivity Analysis of ultrathin Layers on Silicon

The wafer ATR is a unique and powerful *VERTEX* FT-IR accessory for the analysis of ultra-thin layers on single crystal silicon wafers with highest sensitivity. The accessory makes use of the ATR (attenuated total reflection) effect, using the sample itself as ATR crystal. By multiple internal reflections inside the wafer the signal of the ultra-thin layer is therefore strongly amplified.

- Investigation of ultra-low k layers, SiN plasma layers, self-assembled monolayers and many more in the range >1500 cm^{-1}
- For layer thickness down to the low nanometer range
- Strong signal amplification by multiple internal reflection inside the wafer

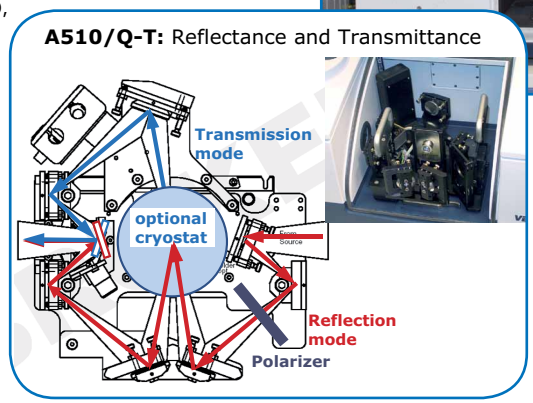




Reflectance & Transmittance for Semiconductor Research and Development

FT-IR Reflectance and Transmittance spectroscopy on semiconductors is a powerful tool for research and development. In combination with the broad spectral range of *VERTEX* spectrometers configurable from far infrared to VIS/UV there are various applications in the semiconductor field.

- Investigation of phonons, bandgap, excitons, doped semiconductors, free carriers, semiconductor based photonic crystals and other metamaterials
- Broadest spectral range from far infrared to VIS/UV and with VERTEX 80/80v highest spectral resolution down to 0.06 cm^{-1} (~7µeV)
- Sample compartment cryostat for low temperature measurements down to ~4K



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