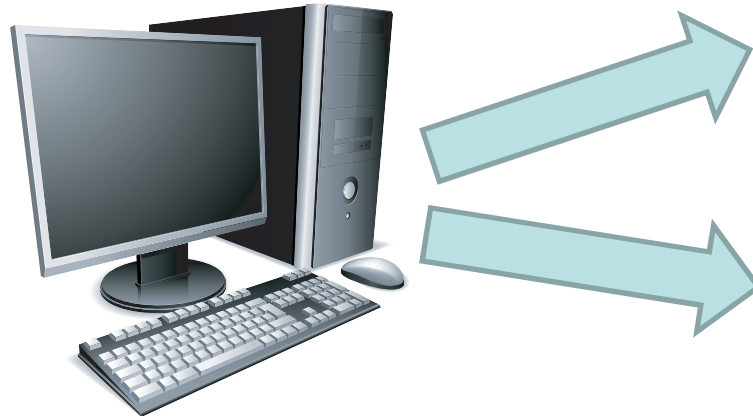


B&W TEK @ *IRUG* 2016

Mobile Spectroscopy Solutions

Our Business

Mobile is the Trend & It is Our Business!



Replacing with Laptop at the same power



Tablet & Smart phone with Apps

How many are still using desktop PC?



Bulky and expensive Lab Instrument



Portable Instrument for Lab & Field use



Handheld for specific Apps

Mobile Spectroscopy Solutions

Health Environment safety

Health Environment safety



Sales and Channels

Sold into 60+ countries

70+ Global
Distributors for
Portable/HH

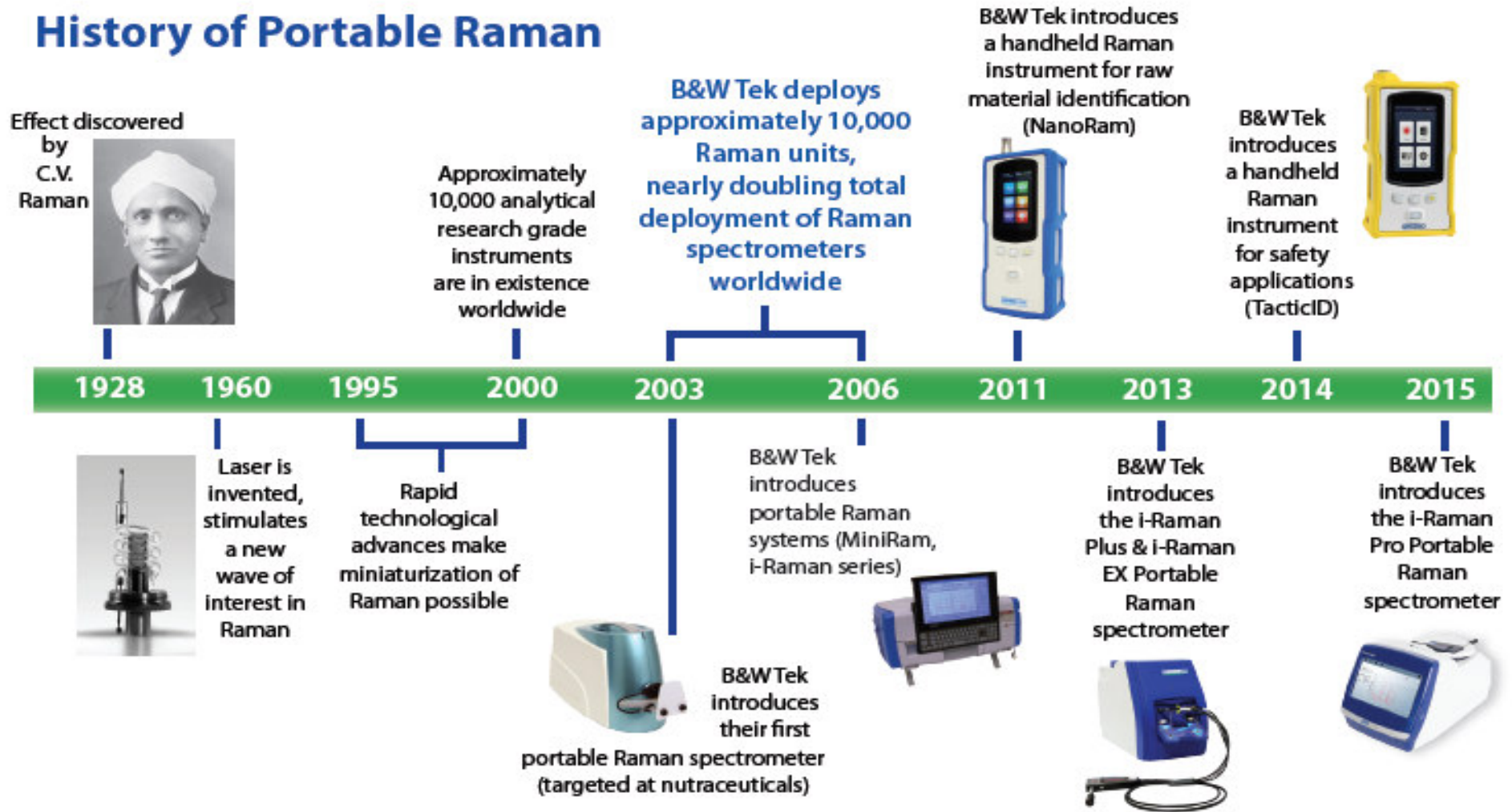
7 Certified
Service Centers

Direct in US for
Portable/HH



Over 10,000 end-users

History of Portable Raman



Handheld Raman Family



Handheld Raman Applications

Incoming raw material inspection for Pharma

Narcotics Identification in Drug enforcement

Explosive & Hazardous Material Identification for 1st Responders

At-line Sampling & Final Inspection of API & formulated product

Food Safety & Counterfeit Detection

Medical Diagnosis





i-Raman Plus

Portable Raman Family



GemRam



i-Raman



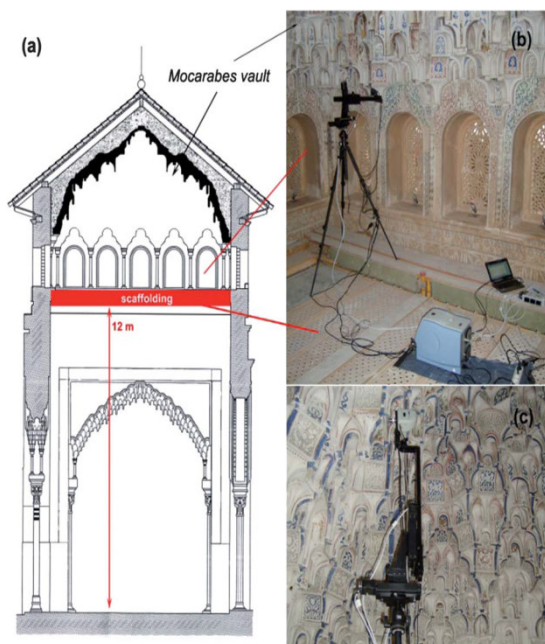
i-Raman Pro



i-Raman EX



Portable Raman for On-site Analysis



- Rugged design
- No moving parts for reliability
- Small size for full portability allowing for on site analysis
- Light weight
- Fiber probe for easy sampling
- Battery option
- High performance to cost ratio

Ref: A. Dominguez-Vidal et al, Analyst, 2012, 137(24), 5763. Reproduced with permission of the RSC

i-Raman®
in
Sverrefjell
Volcano,
Norway



Portable Raman Applications

Academic Research & Teaching

Art And Archaeology

Materials
Science

Forensic
Analysis

(PAT) Process
Monitoring

Bioscience & Medical
Diagnosis

Pharmaceutical &
Chemical QC lab.



Portable Raman System Comparison Chart

A Full Range of Raman Solutions: Field Portable to Research Grade



System:	I-Raman®		I-Raman® Plus		I-Raman® Pro	I-Raman® EX	GemRam™
Laser Excitation (nm)	532	785	532	785	785	1064	785
Laser Power (mW)	50 Max	420 Max	50 Max	420 Max	420 Max	499 Max	420 Max
Spectral Range (cm ⁻¹)	150 - 4000	150 - 3200	150 - 4200	150 - 3350	65 - 3200 ~4.5 @ 912cm	100 - 2500 ~9.5 @ 1296nm	150 - 2700 ~3.5 @ 912nm
Spectral Resolution (cm ⁻¹)	4.5 @ 614nm	4.5 @ 912nm	4.5 @ 614nm	4.5 @ 912nm			
Detector	10°C TE Cooled Linear Array		-2°C TE Cooled High Quantum Efficiency CCD Array		-25°C TE Cooled High Quantum Efficiency CCD Array	-20°C TE Cooled InGaAs Array	10°C TE Cooled Linear Array
Dynamic Range	1300:1		50,000:1		50,000:1	> 100,000:1	1300:1
Sampling	Lab Grade Probe (Trigger Optional)		Lab Grade Trigger Probe		Lab Grade Trigger Probe	Lab Grade Probe (Trigger Optional)	Lab Grade Probe
Power Adaptor	5V DC at 8 Amps		12V DC at 6.6 Amps		12V DC at 6.6 Amps	12V DC at 6.6 Amps	5V DC at 8 Amps
Library	Options Available		Options Available		Options Available	Options Available	Included (>300 Gems)

Portable Raman Software

- BWSpec™
- BWD™
- BWD-Pharma™
- BWIQ™
- GemID™ (Includes Library of >300 Gems)
- Software Development Kit (SDK)

Portable Raman Services:

- Customer Site Application Support
- IQ/OQ Documentation & Implementation
- Method Development
- Library Building
- User Training

Portable Raman Accessories:

- Immersion Shafts with Disposable Sleeves
- Video Microscope Sampling Systems
- Cuvette Holders / Liquid Vial Holders
- **Industrial Grade Probes**
- Tablet Holders
- Probe Holders
- Flow Cells

Handheld Raman System Comparison Chart

A Full Range of Raman Solutions: Field Portable to Research Grade



System:	NanoRam®	TacticID®-GP	TacticID®-N
Laser Excitation / Power	785nm / 300mW Max		
Spectral Range / Resolution	176 - 2900 cm ⁻¹ / -9 cm ⁻¹ @ 912nm		
Dynamic Range	1300:1		
Detector	TE Cooled Linear CCD Array	Linear CCD Array	
Sampling Attachments Included	Point & Shoot, Liquid Vial Holder, Large Bottle Adaptor, Polystyrene Standard	Point & Shoot, Polystyrene Standard	
Onboard Analysis	On Screen Results, User Friendly (NOS)	On Screen Results, User Friendly (TOS)	
Power Adaptor	Rechargeable Li-ion Battery, 12V DC, 2A Min	Rechargeable Li-ion Battery, 15 - 19V DC @ 1.5A	
Libraries	USP Library Included Additional Libraries Available	5,000+ Explosives, Chemicals, Toxic Industrial Chemicals, Chemical Warfare Agents, Plus TacticID-N Libraries	-1,000 Narcotics, Prescription Drugs, Synthetics, Cutting Agents, & Precursors
Barcode Reader	Linear and 2D Standards	Not Available	
Compliance	21 CFR Part 11 Compliant / IP64 Rated	IP65 Rated	
Analysis Modes	Investigation Mode: "Match / No Match" (HQI) Identification Mode: "Pass / Fail" (p-value)	Investigation Mode: "Match / No Match" (HQI)	

Handheld Raman PC Based Software:

- NanoRam ID (NID)
- TacticID Software (TID)

Handheld Raman Services:

- Library Building
- Method Development
- User Training
- IQ, OQ, PQ Documentation
- Customer Site Application Support

Handheld Raman Accessories:

- Point and Shoot
- Right Angle
- Bottle Adapter
- Distance Regulator
- Vial Holder
- Tablet Holder
- Immersion Probe
- Polystyrene Standard

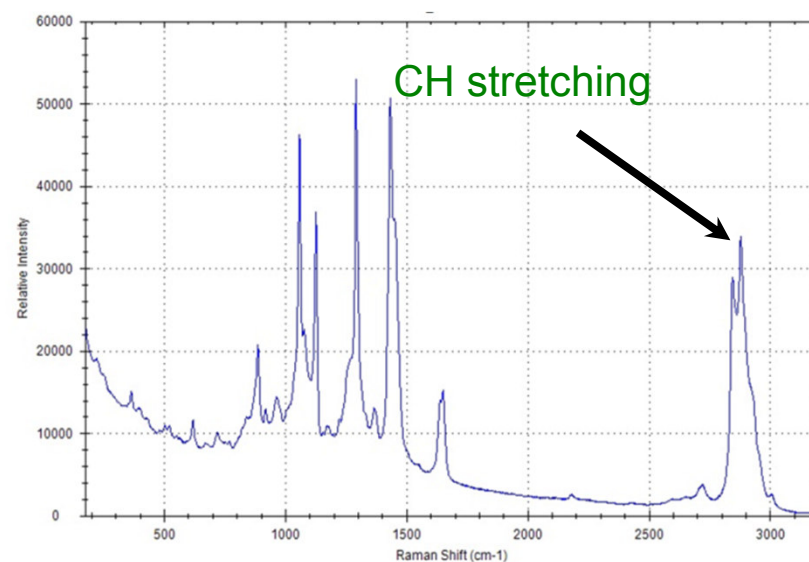
i-Raman® Plus Technical Specifications



Laser		
532nm Excitation	>40mw at laser port (50mW max)	
785nm Excitation	>320 mW at laser port (420 mW Max)	
Laser Power Control	0 to 100%	
Spectrometer	Range	Resolution*
BWS465-532S	150 - 4200cm ⁻¹	< 4.5 cm ⁻¹ @ 614nm
BWS465-532H	150 - 3400cm ⁻¹	< 3.5 cm ⁻¹ @614nm
BWS465-785S	150 - 3350cm ⁻¹	< 4.5cm ⁻¹ @ 912nm
BWS465-785H	150 - 2800cm ⁻¹	< 3.5cm ⁻¹ @ 912nm
Detector		
Detector Type	High quantum efficiency CCD Array	
Pixel Number	2048 Effective Detector Elements	
Effective Pixel Size	14µm x - 0.9 mm	
CCD Cooling Temperature	-2°C	
Dynamic Range	50,000:1 (Typical)	
Digitization Resolution	16-bit or 65,535:1	
Integration Time	100ms - 30 mins	
Electronics		
Computer Interface	USB 3.0 / 2.0	
Trigger	Yes (Compatible with BWTek Probes)	
Power Options		
DC Power Adaptor	12V DC @ 6.6 Amps	
Battery	Optional	
Physical		
Dimensions	6.7in x 13.4in x 9.2in (17cm x 34cm x 23.4cm)	
Weight	-6.6lbs (-3kg)	
Operating Temperature	0°C - 35°C	
Storage Temperature	-10°C - 60°C	
Humidity	10% - 85%	

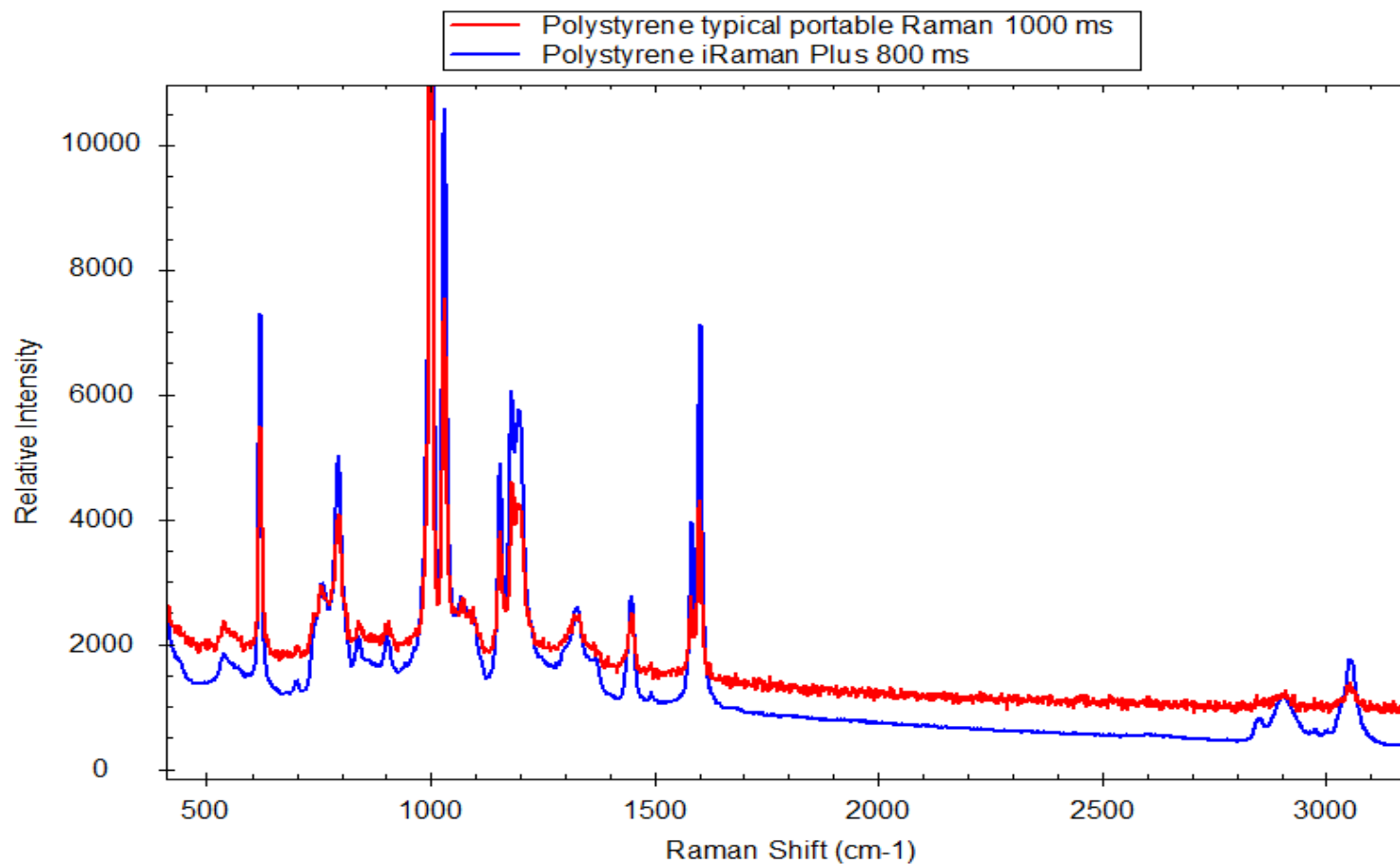
i-Raman® Plus

- Small footprint, lightweight, low power consumption- excellent performance
- Raman shift range up to 3350 cm^{-1} (4200 for 532 nm system) covering C-H stretching modes
- Comprehensive suite of accessories, and software, allow versatility and portability
- BWIQ® for quantitative analysis;
- BWID® for identification with user-defined or purchased Raman spectral libraries



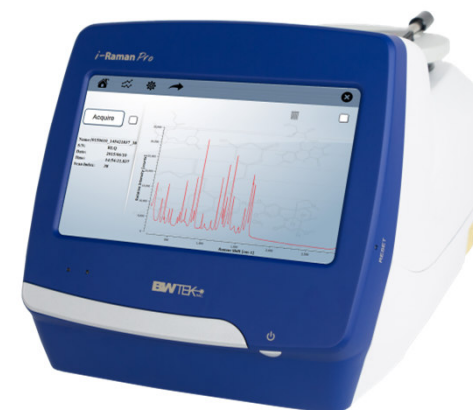
Improved Signal to Noise with *i*-Raman® Plus

BWS465-785S-BAS Polystyrene iRaman Plus 800 ms : Dark_Subtracted



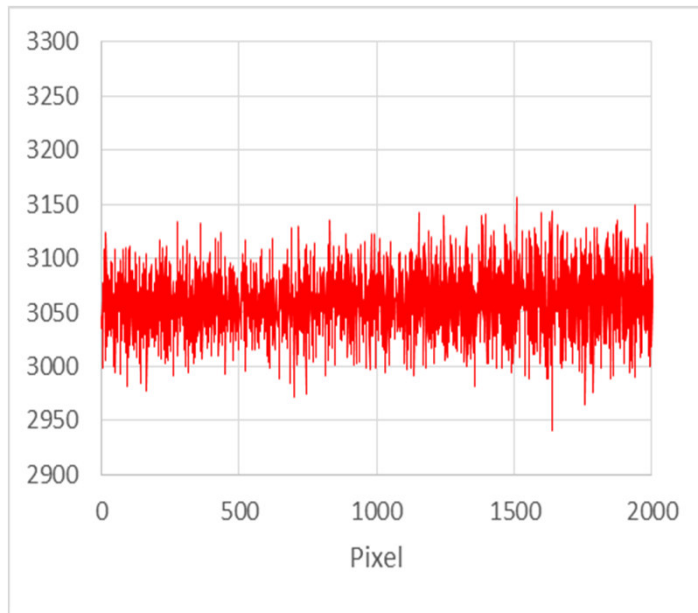
i-Raman® Pro

- Fully integrated portable Raman spectrometer operating with fiber optics probe and covering spectral range from 65-3350 cm^{-1} with 785 nm excitation
- Deeper cooling than other *i*-Raman® series (ΔT of -55C): better performance for long integration times and low scatterers
- Low readout noise: the default full vertical binning readout mode results in lower readout noise and faster speed.
- Compact mobile design with integrated tablet PC operating touch-friendly BWSpec® Mobile software; operation with external computer and BWSpec® also available

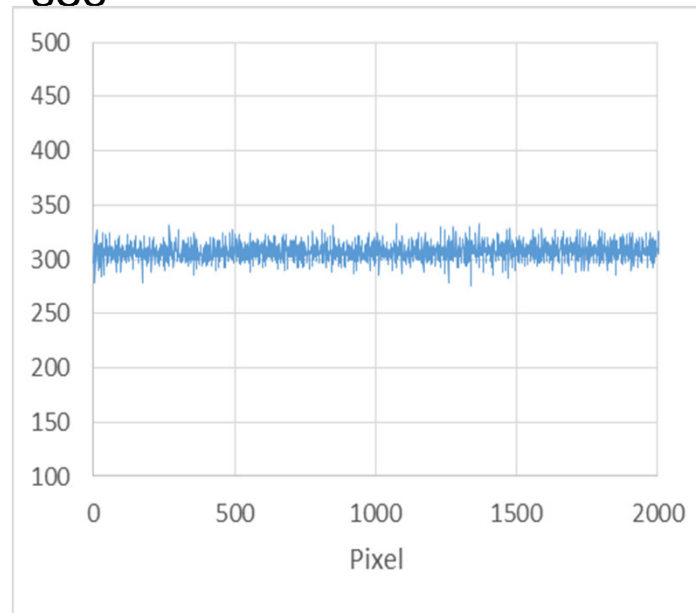


Readout Noise Comparison

i-Raman® Plus: default, 0.1 sec

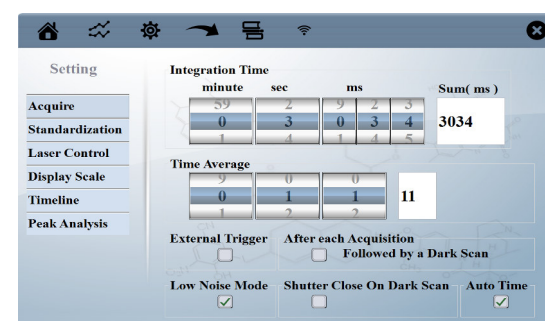
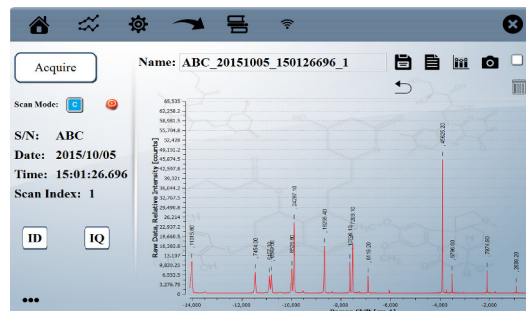
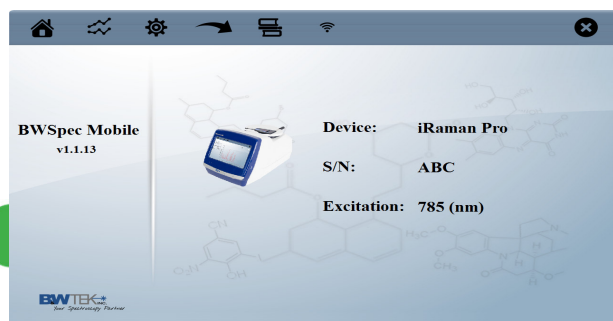


i-Raman® Pro: Linear Mode, 0.1 sec



BWSpec® Mobile

- Touch-friendly operation using embedded tablet computer
- Acquire data in single or continuous mode
- Overlay of spectra; view microscope image
- Swipe control to review collected data
- Database storage of data; ability to export spectra in several data formats



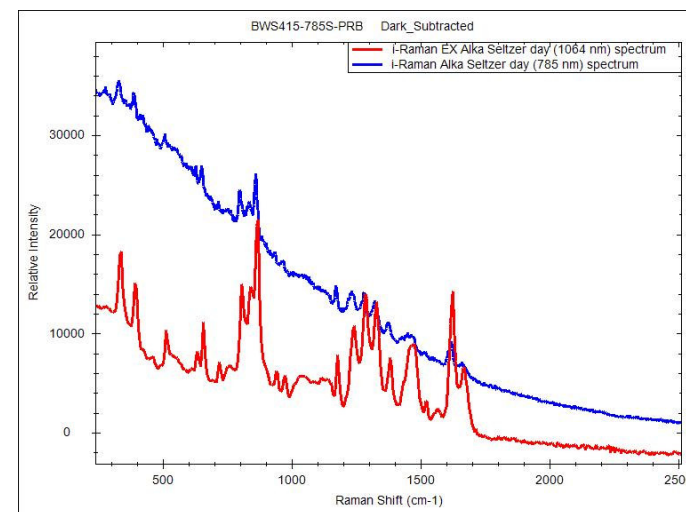
i-Raman® EX Technical Specifications



Laser		
1064nm Excitation	>430mW at laser port (499 mW max)	
Laser Power Control†	0 to 100%	
Spectrometer	Range	Resolution*
i-Raman-1064S-05	100cm ⁻¹ - 2500cm ⁻¹	~ 9.5cm ⁻¹ @ 1296nm
Detector		
Detector Type	TE Cooled InGaAs	
Dynamic Range	> 100,000:1	
Digitization Resolution	16-bit or 65,535:1	
Integration Time	200 μs to >30 minutes	
Pixel Number	512	
Effective Pixel Size	25μm x 250μm	
CCD Cooling Temperature	-20°C	
Electronics		
Computer Interface	USB 2.0 / 1.1	
Trigger	Yes (Compatible with BWTek Probes)	
Power Options		
DC Power Adaptor	12V DC @ 6.6 Amps	
Battery	Optional	
Physical		
Dimensions	6.7in x 13.4in x 11in (17cm x 34cm x 28cm)	
Weight	Main Unit ~7.6 lbs	
Operating Temperature	0°C - 35°C	
Storage Temperature	-10°C - 60°C	
Humidity	10% - 85%	

i-Raman® EX

- Material fluorescence reduces Raman applicability on a small subset of materials – especially those that are highly colored; dyes and pigments
 - Utilize 1064 nm excitation
 - Reduce fluorescence
 - Increase productivity vs. other techniques
 - Research grade instrument provides enhanced material characterization opportunities



Sampling

- Fiber optic probes can be easily adapted to a variety of different sampling configurations
 - Liquid flow cells
 - Gas flow cells
 - Optical microscopes
 - Probe holder
 - Cuvette or vial holder
 - Tripod for use with video microscope



Fiber Optic Probe

- Standoff or direct contact with sample
- Lab grade and industrial probes
- Needle probes
- Fiber optic probes can be customized for laboratory and industrial environment
 - Shaft length and material
 - Working distance
 - Window material
 - Fiber length



BAC102:
Lab grade trigger probe –
standard



BAC 101
Industrial grade probe

Slide 22

k1

probe picture in action

katherineb, 8/8/2013

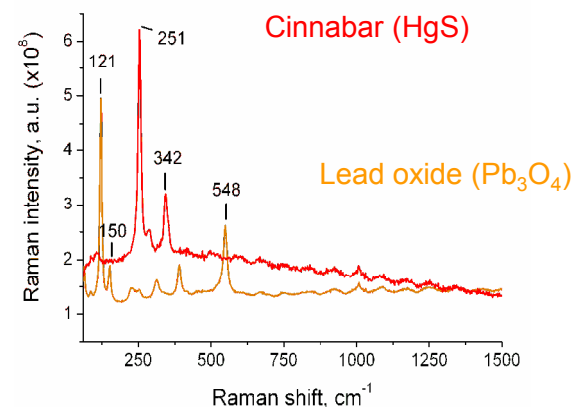
Portable Video Microscope Sampling System (BAC151B)

- Compatible with all B&W Tek Raman probes
- Precise target and focusing
- Good for precise measurement of small sample volume
- Digital camera and LED illuminator
- Coarse and fine XYZ adjustment
- Standard objectives from 10x to 100x
- Bright and dark field illumination for various sample surfaces
- Low cost and portability



Applications in Art & Archaeology

- Portable Raman spectroscopy is widely used for the analysis of paintings, ceramics, statues (surface coatings), documents, and other artifacts.
- The flexibility of portable instrumentation with fiber optics in conjunction with the non-destructive & non-contact nature of Raman allows measurements to be taken *on-site*.
- Raman can measure inorganics as well as organics, providing valuable information about paints, dyes, pigments and building materials and their origin and age.
- Spectral range extending as low as 65 cm^{-1} , important in distinguishing pigments and crystalline form



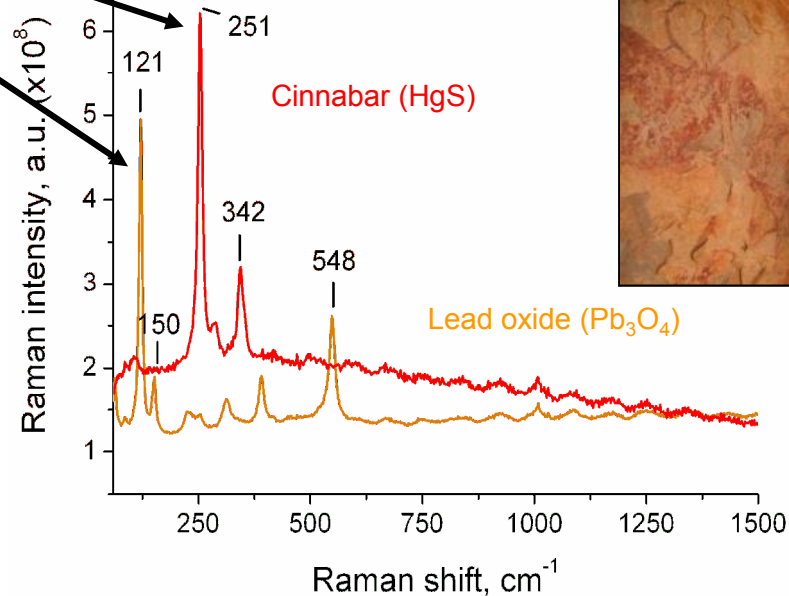
Portable Raman Microscopy of Ancient Pigments

Portable Raman allows for field measurements such as that of pigments on the ceiling of a cathedral in Spain and in caves.

The *i*-Raman® spectrometer is connected to a tripod-mounted video microscope for precision alignment.

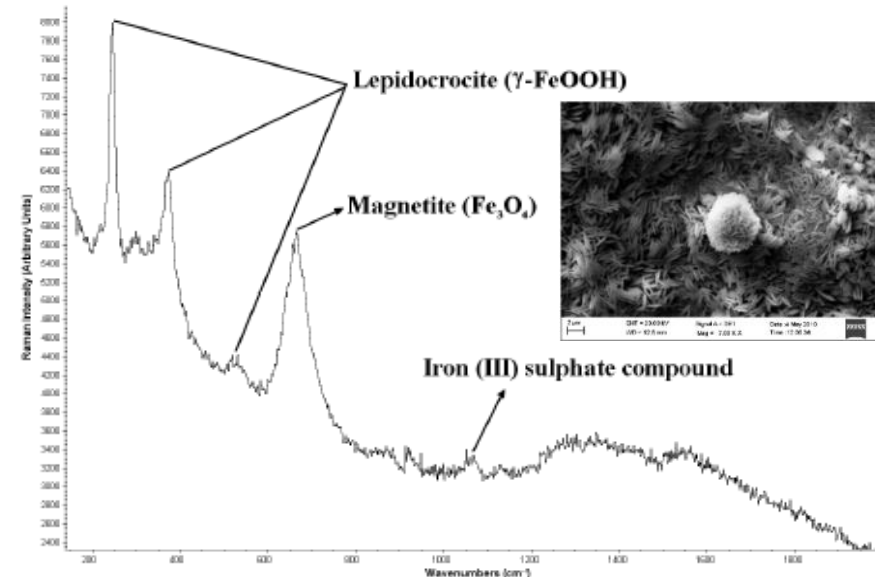


Courtesy of M.J. Ayora Cañada y A. Dominguez Universidad de Jaén



Analysis of Metal Corrosion

- Raman spectroscopy was used at the Guggenheim Museum in Bilbao Spain to analyze environmental effects on the corrosion of seven steel sculptures from Richard Serra.
- The figures below show the presence of lepidocrocite, magnetite, and iron sulfate from Richard Serra's Inverse Blind Point sculpture, as well as a SEM image of the surface confirming the results of the Raman analysis



K. Castro et al., COST Action D42 Extended Abstract. 2011, 113–116

Applications in Geology and Mineralogy

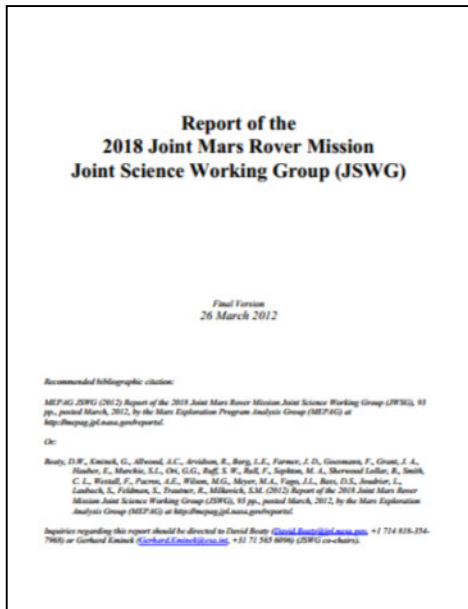
- Portable Raman spectrometers are ideal for the identification of gemstones and minerals, including polymorphs and isomorphs.
- Non-contact, non-destructive sampling allows for analysis of precious or scarce samples, unlike other techniques such as LIBS.
- Anti-counterfeiting of precious, such as identification of diamond from zircon



Raman Evaluated for Geological Survey on Mars

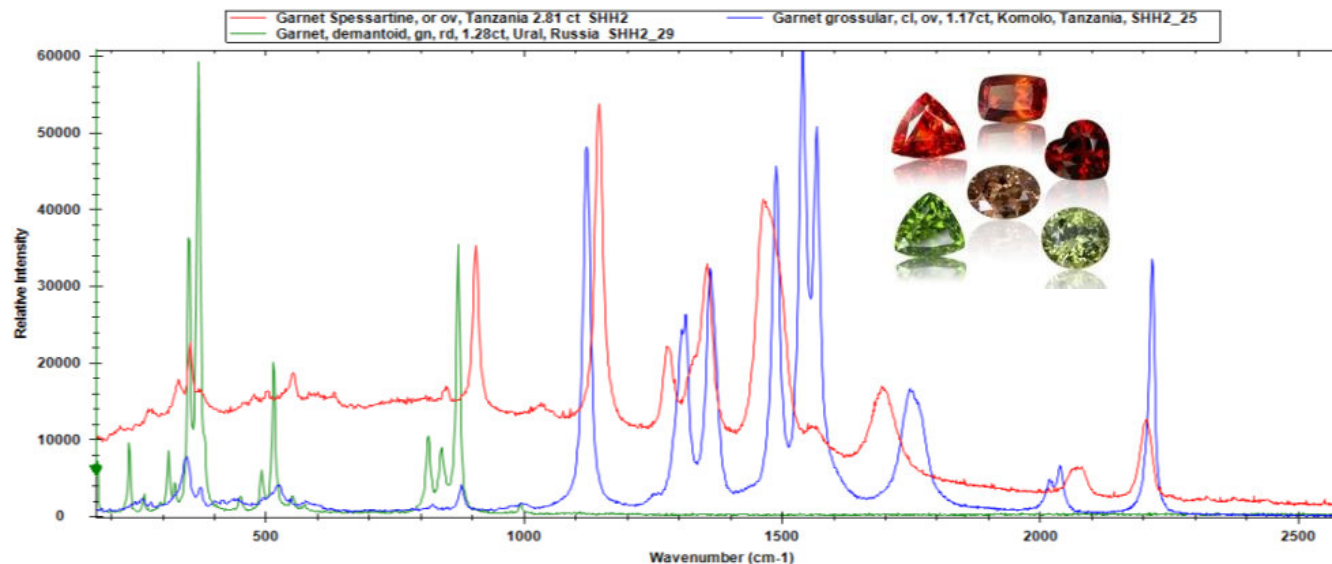
Before testing for life on other planets, feasibility studies are done on barren areas of the Earth.

i-Raman® spectrometers were evaluated for use in geological surveys of rocks and ice structure in Svalbard, Norway and Rio Tinto in Spain, where conditions are analogous to Mars

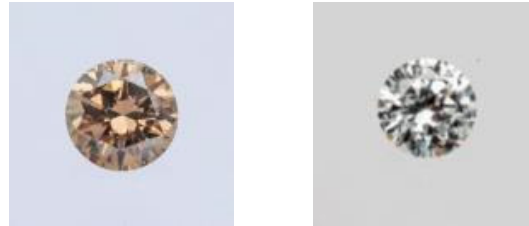


Analysis of Garnet Gemstones

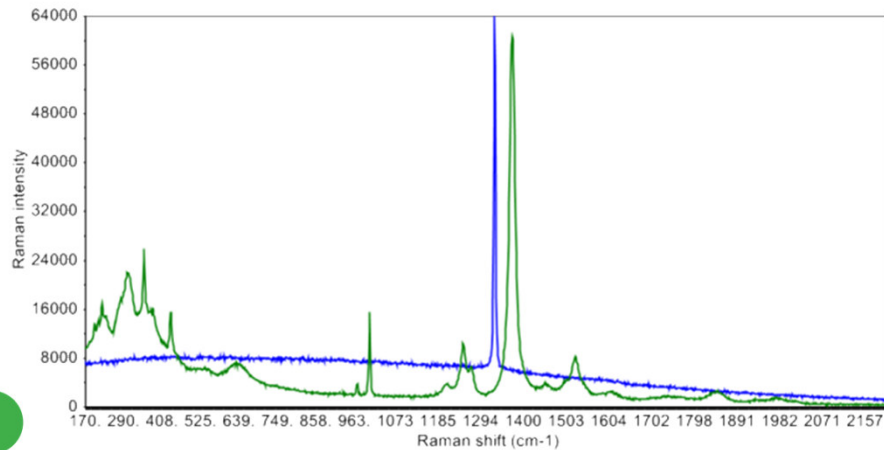
- Garnets are a class of silicate minerals which include a number of varieties with the general form $X_3Y_2(SiO_4)_3$.
- Raman spectroscopy's high selectivity allows for the differentiation of the garnet varieties. Andradite and grossular fall into the ugrandite group of garnets (calcium in X site), while spessartine falls into the pyrospite group (aluminum in Y site).



Diamond or Zircon?



— Diamond — Zircon crystal



- Raman spectra of diamond and zircon are distinctly different
- Diamond shows only one very strong and sharp Raman band at around 1328 cm^{-1} , which corresponds to the C-C stretching mode.
- Zircon shows multiple Raman bands at around 349, 431, 967 and 1002 cm^{-1} , which correspond to the Si-O bending mode and stretching mode.

Thank you for your attention

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