Nanofinder® HE
3D Laser Raman Microspectroscopy System

AFM (STM) Raman microscopy
Near-field microscopy TERS, SNOM
3D Confocal Raman spectroscopy

株式会社 東京インスツルメンツ
TOKYO INSTRUMENTS, INC.
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AFM-Raman High End spectroscopy system

**AFM-Raman**
AFM-Raman configurations: reflection and transmission
Simultaneous measurement of surface topography and confocal Raman imaging
High speed: < 3 ms / point
(with simultaneous full spectrum and AFM signal saving)*

**Near-field Imaging**
TERS (Tip Enhanced Raman Spectroscopy)
SNOM (Scanning Near Field Optical Microscopy)
Spatial resolution: < 80 nm by near-field technology

**3D Confocal Raman Microscopy**
High sensitivity: Detection of weak 4th order Si peak (1 min.)*
High spatial resolution: Below 180 nm lateral, 400 nm axial (with immersion objective lens)*
High mapping speed: < 3 ms / point (with full spectrum saving)*
Prototype (The exterior appearance of the product will be slightly different.)
Multi-configuration microscope

Up-right, Inverted, Transmission and Inverted-Transmission

Built-in microscope configurations are available.
Optical path of laser excitation and Raman signal detection can be changed with 3 sliders.

1. Up-right Microscope Configuration
   - Laser → TV-CCD → Objective → Sample → Raman

2. Inverted Microscope Configuration
   - Laser → Raman

3. All-In-One Microscope Configuration
   - Optical path switch
   - Up-right Configuration
   - Inverted Configuration
   - Transmission (Top-to-Bottom) Configuration
   - Transmission (Bottom-to-Top) Configuration
Multiple scanner configurations

Piezo-stage, Step-motor, AFM, etc. (more than 10 different configurations are available)

Configuration examples

Confocal Raman upright microscope after sliding AFM head

AFM-Raman transmission microscope

AFM-Raman inverted microscope

AFM-Raman upright microscope
Multi-configuration microscope

High stability: thermal and temporal

Granite Frame *
Thermal and temporal stability are achieved due to a granite frame. Optics, spectrometer and microscope are all installed on a single granite frame in order to avoid mechanical drift of sample, confocal pinhole or spectrometer components.

LED Illuminator
LED illuminator with less heat liberation minimizes thermal strain of the microscope system. In case of illumination ON/OFF and light variation it has negligible heating effect.

Isolated Sample Area
Sample area is protected with a microscope cover. Air flow influence, stray light penetration, acoustical vibrations can be fully suppressed or minimized in the isolated measurement facilities.

Smart Sliding Mechanism
This mechanism enables the user to move the focusing unit smoothly up and down using weight compensation spring and air suspension lever. Positioning reproducibility of the focusing unit is below 1 μm.

Large working space * amplifies potential applications
Large working space under the objective lens 345(W) × 385(H) × 330(D) mm allows the user to install various equipment, such as piezo stage for high resolution Raman imaging, AFM, cryostat, heating & cooling stage, high pressure chamber, magnetic facilities, etc.
Upright microscope configuration (AFM-Raman)

- Microscope cover
- Cooled CCD detector
- Spectrometer side port
- Microscope with LED and monitoring CCD
- Granite frame
- AFM
- Microscope light control & observation port switch
**High accuracy of spectral data**

**Automatic spectral calibration with built-in hollow cathode lamp**

Spectral calibration is performed automatically when the user changes wavelength range or selects a different grating. It is also possible to confirm current device calibration by pressing a single button on the program interface at any time.

**Precise calibration algorithm**

Based on spectrometer geometry the calibration algorithm ensures spectrum accuracy within 1 pixel of CCD detector.

**Rich spectrum of hollow cathode lamp**

Precise spectrometer calibration is possible for any grating (including echelle type) at any wavelength range due to large number of spectral lines.

**High spectral resolution**

**High resolution spectrometer**

Focal length of 550 mm.

**High aberration quality**

Spectral line width (FWHM) of 24 μm on CCD detector can be achieved.

**Echelle grating**

Echelle grating grants dramatical increase of spectral resolution by utilizing higher diffraction orders.

**Automatic self alignment**

**Built-in motorized mirror**

Motorized tilt control ensures exact Raman signal positioning onto a true pinhole. Pinhole consists of 2 independent motorized orthogonal slits.

**Computer controlled alignment**

Software ensures mapping of Raman signal onto confocal pinhole and placing the signal in optimal position. Fine confocal alignment can be done within 1 min.
**Advanced system design**

*High throughput*
Throughput of optical path from laser to sample and from sample to detector is within 30–40% (taking into account all losses in optical elements, microscope objective lenses, spectrometer).

*Polarization option*
High polarization purity is based on Glan-Taylor prisms and motorized high accuracy retardation plates. Glan-Taylor prism in the detection channel has motorized control for inserting it in and removing it from the optical path as well as selection of polarization orientation.

*Motorized exchangeable optics for UV, VIS and NIR*
Laser beam expanders in illumination channel and objectives for confocal pinhole in detection channel are prealigned in motorized turrets for fast and easy automatical switching.

*Fully motorized excitation laser switching*
4 excitation laser wavelengths can be switched with step-motor control of laser mirror positions, retardation plates turret, beam expanders turret and edge-filters turret. Full system configuration can be saved and automatically recovered.
Advantage of the Nanofinder HE is the ultrafast 3D Raman imaging based on scanner-detector synchronization with the highest sensitivity and the highest spatial resolution. It is achieved by employing a high throughput optical system, fast and high sensitive CCD detector and high accuracy piezo stage.

### 3D Confocal Raman Points

- **Highest Sensitivity**
- **Highest Spatial Resolution (XY < 200 nm)**
- **Highest Speed Up to< 3 ms / point (full spectrum saving)**

### Highest Sensitivity

High sensitivity of Nanofinder HE is confirmed by its ability to clearly reveal the 4th-order Si Raman overtone within short exposure time (Fig.1).

Intensity of the Si Raman peak at 520 cm⁻¹ (1st-order) is usually strong, but higher overtones show much weaker signal. Therefore, detection ability of higher orders of Si Raman peak may be considered as a sensitivity benchmark of a Raman spectroscopic system.

High sensitivity of Nanofinder HE permits the user to minimize the excitation laser power and, therefore, to avoid sample modification or damage.

![Fig. 1 Si Raman spectrum of the higher order overtones](image)

**Measurement conditions:**
- Excitation laser 8.6 mW@473 nm, measurement time 60 sec
- Microscope objective lens : 100×0.95

### Highest Spatial Resolution

Laser Confocal mapping image of Si / SiO₂ line&space sample is shown in Fig. 2. Mapping is done in XZ direction (X-axis along the sample surface, Z-orthogonal to the sample surface). Data show a lateral resolution (edge response, when signal rises from 10% to 90%) of 170 nm and an axial resolution (FWHM of reflection from sample surface profile) of 380 nm with water-immersion microscope objective lens.

![Fig. 2 Laser confocal image of Si / SiO₂ line&space 1μm / 1μm](image)

**Measurement conditions:**
- Excitation laser 473 nm, Pinhole 18μm, mapping step 50 nm
- Microscope objective lens : 100×1.25
High Speed

Employing the cutting-edge EMCCD detector, Nanofinder® HE provides sample measurement with the highest sensitivity, the highest accuracy and the highest speed (up to 3 ms), saving full Raman spectra at every mapping point. TII advanced technology solutions give the fastest scanning procedure in the closed-loop mode.

About 25 seconds are required to implement mapping with 100×100 points (X,Y), 3D image with 100×100×30 (X×Y×Z): 300,000 points in ultra-fast scan mode takes only 12.5 min (for comparison, point-by-point mapping mode takes about 2 hrs 45 min for the same image resolution.)

2D Raman Imaging examples

Cross-Hatch pattern of stress distribution of Si grown on SiGe virtual substrate

Measurement of Amorphous Si thin film crystallization

Study of metabolic activity in the living cell.
During the mapping procedure, 2D or 3D image cross-sections can be observed in real time. The Nanofinder® HE unique software has advanced abilities to display and analyse data. Various data processing and presentation tools are available. The Nanofinder® HE software can easily handle huge volumes of 3D mapping data with full Raman spectrum at every point.

**Saving measurement time & optimize experimental conditions**

Usually it takes a lot of trial measurements to determine appropriate experimental conditions to get good quality mapping images. The Nanofinder® HE software real time display provides the possibility to analyze data during the measurement. Fast data visualization allows fast parameter adjustment, area exchange and measurement restarting.

**Data analysis capability**

During the mapping procedure, all spectra from every measurement point (X,Y,Z) are stored in the computer memory. Nanofinder® HE software provides various imaging functions, such as Raman peak intensity, peak shift, peak bandwidth, etc. Built-in image calculator provides more sophisticated functions for visualization, such as image filtering, image subtraction, peak intensity ratio, etc. Deconvolution and curve-fitting functions can enhance spatial and spectral resolution.

**Imaging data analysis**

Measured 3D data can be easily examined from arbitrary angles (Fig. a). Position and orientation of 2D cross-sections can also be arbitrary selected (Fig. b, d). 1D cross-sections provide distance measurement and intensity plot profiling (and other imaging functions) along arbitrary directions (Fig. c,f). The pointing tool shows Raman spectra at specified mapping points (Fig. g). Multiple color schemes provide powerful tools for impressive image coloration.
3D Raman images of self-assembled liquid crystal (Raman intensity image at 1136 cm⁻¹)

Fig. a  
3D Raman image

Fig. b  
X-Y cross section image in depth direction

Fig. c  
Top view of the X-Y cross section

Fig. d  
Image 2D cross-section at arbitrary place and angle

Fig. e  
Quasi 3D image of intensity expressed by color and height

Fig. f  
Cross-section intensity profile and distance measurement along the white line B in Fig. c

Fig. g  
Raman spectrum of self-assembled liquid crystal (Point A in Fig. c)

Fig. h  
Example of 2D image deconvolution application (Si device). Shape correction and sizes decreasing are clearly observed.
Combination of confocal Raman system Nanofinder® HE with AFM allows simultaneous measurements of AFM topography and Raman confocal image of the same sample area. Such correlated topography (AFM) and chemical composition (Raman spectroscopy) data are useful for defect evaluation of semiconductor devices, carbon nanotube analysis, foreign material detection, etc. Different AFM modes (e.g., Phase, Lateral Force, Kelvin Probe, conductive AFM or STM) can be performed simultaneously with confocal Raman mapping.

The AFM used with Nanofinder® HE is designed especially for combined operation with this confocal Raman system. With an IR laser wavelength of 1300 nm there is no influence between the AFM feedback control system and the Raman system. The design concept of the AFM was focused on full device automation, easy to use, easy to exchange cantilever or sample, easy combining with confocal Raman system (by hardware and software), high stability and small drift for long time measurements.

**AFM-Raman Point**

- Simultaneous Same Sample Area Measurement by AFM and Confocal Raman
  - with 1300nm AFM feedback laser there is no crosstalk between AFM and Raman systems
- Different AFM models for various configurations are available.

**One AFM head for both: reflection and transmission AFM / Raman geometries**

While typical AFM / Raman systems have different AFM heads for Reflection and Transmission configurations (combined with Up-right and Inverted microscopes correspondently), the Nanofinder® HE AFM (CombiScope™1000) uses only a single head and a single built-in microscope for both Reflection and Transmission configurations with the possibility of prompt (without sample and tip position change) switching between them.

**Automated alignment mechanism**

AFM measurement can be started promptly after the automated preparation procedures (locating of laser spot on cantilever, positioning sensor adjustment) With fully automated resonance search, feedback control tuning, approaching and landing, even beginners can get the first AFM mapping result within a few minutes after the system start.
Access to sample with high NA objective lenses

Especially designed for combined operation with confocal Raman, the AFM of Nanofinder®HE has the best optical access to the sample / probe area: microscope objectives of 100×NA0.7 (from top for opaque samples) and 100×NA1.3 (from bottom for transparent samples) can be applied for simultaneous combined AFM-Raman measurements. As a result, spatial resolution below 50 nm can be achieved in TERS measurement.

Advanced sample position adjustment

The AFM (SmartSPM™1000) is equipped with motorized XY sample positioning system, which ensures the capability of easy returning to (or switching between) points / areas of interest. Fine closed-loop XYZ piezo-scanner, equipped with capacitive sensors, is used for AFM and confocal Raman mapping. The motorized XY stage provides precise sample positioning and the piezo driven XYZ piezo stage ensures fine mapping images.

Focused laser spot / AFM probe position adjustment

Closed loop objective lens scanner is employed for automatical laser spot / AFM tip apex fine alignment. Preliminary alignment can be done motorized (CombiScope™1000) or manually with microscrews(SmartSPM™1000).

True non-contact mode

True non-contact mode operation is ensured by fast 300 MHz Digital Signal Processor (DSP). Non-contact scanning mode at reduced amplitudes of probe oscillation is optimal for soft samples or delicate AFM probes, avoiding damage of sample or probe due to no sample / probe contact.
**AFM-Raman**

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### Up-right Microscope Configuration

**AFM model:**
**AIST-NT SmartSPM 1000 with HE002 head**
AFM tip and Raman excitation laser beam - both approach sample from top:
Selection for opaque samples.
Advantages:
- High resonance frequency scanner (X,Y - 7 kHz; Z-15 kHz).
- True Non-Contact AFM for best performance
- Fastest AFM mapping possible

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**Applicable to** Reflection TERS

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### Inverted Microscope Configuration

**AFM model:**
**AIST-NT CombiScope 1000 with HE002 head**
AFM tip approaches from top; laser beam comes from bottom:
Selection for samples distributed on thin transparent substrates (e.g. microscope cover glass)
Advantages:
- High NA (up to 1.3) microscope objective lenses applicable;
- Operation in liquid possible (for HE001 head);
- Switchable magnification: microscope objective lenses change without sample removing

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**Applicable to** Transmission TERS
All-In-One Microscope Configuration* (with Up-right, Inverted, Transmission and Inverted Transmission)

AFM model:
AIST-NT CombiScope 1000 with HE002 head
AFM tip comes from the top; laser beam can come from both: top and bottom, beam path change within a few seconds. Can work with both: transparent and opaque samples
Advantages:
- Universality (Reflection & Transmission geometries possible)
- Transmission SNOM with cantilever based sensors is available

Applicable to both: Reflection and Transmission TERS

High Grade Scanning Probe Microscope AIST-NT SmartSPM 1000: performance examples

100 nm topography scan of C_{60}H_{18} molecules on HOPG. Z range: 1.3A. Non contact mode.

1.4 micron topography image of the Plasmid DNA. Semiconact mode in buffer solution.

Topography image of 130 nm Ag nanoparticles immobilized on the metal surface.

Single layer flakes of Graphene Oxide deposited on functionalized mica, AFM topography image.

Atomic resolution STM image of HOPG using unique 100 x 100 microns scanner. Constant Current mode.
Tip-enhanced Raman spectroscopy (TERS) is a novel method for getting Raman spectra/images with high spatial resolution far beyond the diffraction limit of light. Near-field light is generated at the tip apex of a metal coated sharp probe (10−30 nm). Tokyo Instruments, Inc. commercialized the world’s first reflection TERS imaging system.

**Tip-Enhanced Near-field Raman Microscopy**

**TERS: Tip-Enhanced Raman Spectroscopy**
High spatial resolution < 50 nm by near-field Raman spectroscopy with AFM metal coated probe

**Measurement principle**

The basic system configuration for TERS is similar to AFM-Raman combined system. AFM probe for TERS is a Si tip coated with noble metal (Au or Ag) instead of bare Si probe used for just combined AFM-Raman measurements. First, the AFM probe approaches the sample surface. Then a closed-loop scanning system realizes exact coincidence of the tip apex and the focused laser spot. In appropriate conditions, the localized surface plasmon is generated at the tip apex of the probe. It may enhance the Near Field Raman signal up to thousands times from an area of 10−30 nm around the tip apex. Therefore Raman spectra and images can be measured with a spatial resolution beyond diffraction limit.

**Transmission TERS**

Transmission TERS is the choice when samples (for example, carbon nanotubes or biological cell) are distributed on microscope cover glass.

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Sample: PPN polymer nanoparticles (50−100 nm), deposited on microscope cover glass. Sample and data by courtesy of Dr. S. Nishio, Tohoku University.
Reflection TERS

Reflection TERS is the only way to measure opaque samples. It can be applied for low-dimensional samples such as carbon nanotubes, distributed on Si substrate. Graphene, various nano crystals, strained Si structures are also candidates for TERS measurements in reflection geometry.

**Laser spot-AFM tip position adjustment**

In TERS measurement, the laser spot must be focused exactly on the specific point on the AFM tip apex. A closed-loop piezo-scanning system can arrange exact positioning of the laser spot and the AFM tip.

Microscopic image of the area around the AFM tip apex. Sample is visible even beneath the AFM probe because of very high NA of the microscope objective lens (0.7).

Raman image, obtained by laser spot mapping with objective lens scanner relative to AFM tip apex. Tip is in contact with Si uniform wafer surface. Si peak intensity at 520 cm⁻¹ is used for Raman intensity imaging. It is clear to see the Si wafer enhancement point in specific laser spot position.

**TERS in a single point**

Sample: Si/SiO₂ Line&Space 100 nm

**Simultaneous topography TERS intensity and Stress mapping**

AFM topography  | TERS intensity at about 520 cm⁻¹(Si main peak)  | TERS Raman Shift (Si main peak)
## Detailed specifications

### System configuration

<table>
<thead>
<tr>
<th>All-In-One device</th>
<th>opto-mechanical unit, spectrometer, microscope, multilaser system and controller are integrated in a single case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granite frame</td>
<td>exclusive optical system stability</td>
</tr>
</tbody>
</table>
| Multi-configuration microscope | Up-right, Inverted, Transmission - reconfigurable  
|                   | Bright and Dark-field, Fluorescence observation modes;  
|                   | Microscope objective lens turret, TV-CCD camera                                                     |
| Scanner           | Piezo stage (X-Y-Z) or (X-Y) Stepping Motors or Atomic Force Microscope (AFM)                       |
| Excitation Raman laser | up to 3 built-in plus 1 external port                                                                 |
| Spectrometer      | assembled on granite base plate, f=55 cm, 2 exit ports, 3 motorized gratings on exchangeable turret |
| Detector          | for VIS Raman cooled CCD or EMCCD,  
|                   | for NIR Raman or PL: InGaAs,  
|                   | for Fluorescence Lifetime: APD with TCSPC                                                           |
| Computer, LCD     | 2 monitors in AFM configuration                                                                      |
| Software          | advanced Nanofinder® software set                                                                    |

### 3D confocal Raman spectroscopy

**Mapping range**  
100×100×20 μm with piezo-stage  
*Standard for AFM combined. Larger range stages up to 300×300×100 μm are also available.*

**Mapping speed**  
< 3 ms / point (full spectrum saving) with EM CCD ADC 3 MHz.

- **Spatial resolution (typical):**
  - Laser Wavelength (nm): 473, 532, 785
  - Objective lens 100×0.95 (air): XY (nm) 200, 220, 500; Z (nm) 500, 550, 850
  - Objective lens 150×1.25 (water): XY (nm) 180, 220; Z (nm) 400, 450
  - *For laser line: XY-edge response 10~90 %, Z-surface response FWHM

- **Raman shift measurement range**
  - Laser Wavelength (nm): 473, 532, 785
  - Wavenumber range (cm⁻¹):<br>  
    - Below 150 ~ 60 ~ 60 ~
    - with BR-DD CCD  
    - >4,000  >4,000  >3,000

- **Spectral resolution: spectral line FWHM**
  - Grating (G/mm): 1800, 75 (Echelle)
  - Resolution (cm⁻¹): 0.8, 0.25
  - *Under the following conditions:  
    1. At the CCD center.  
    2. Central wavelength 550 nm.  
    3. CCD pixel size 16×16 μm².

- **Spectral accuracy: within 1 pixel of CCD.**
  - Grating (G/mm): 1800, 75 (Echelle)
  - Accuracy (cm⁻¹): 0.43, 0.1
  - *Under the following conditions:  
    1. Central wavelength 550 nm.  
    2. CCD pixel size 16×16 μm².

*Specifications are subject to change without notice.
### Excitation lasers

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength range</td>
<td>244 nm ~ 1.06 μm</td>
</tr>
<tr>
<td>Number of built-in lasers</td>
<td>max 3</td>
</tr>
<tr>
<td>Port for external laser</td>
<td>Yes</td>
</tr>
</tbody>
</table>

#### Standard built-in laser set (CW for Raman)

<table>
<thead>
<tr>
<th>Laser wavelength (nm)</th>
<th>473</th>
<th>532</th>
<th>785</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power (mW)</td>
<td>20</td>
<td>50</td>
<td>80</td>
</tr>
<tr>
<td>Spatial mode</td>
<td>TEM₀₀</td>
<td>TEM₀₀</td>
<td>TEM₀₀</td>
</tr>
<tr>
<td>M²</td>
<td>&lt;1.1</td>
<td>&lt;1.1</td>
<td>&lt;1.2</td>
</tr>
<tr>
<td>Spectral line width (MHz)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;50</td>
</tr>
<tr>
<td>Polarization contrast</td>
<td>&gt;100 : 1</td>
<td>&gt;100 : 1</td>
<td>&gt;100 : 1</td>
</tr>
</tbody>
</table>

#### Picosecond diode lasers for FLIM

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Wavelength range</td>
<td>375 ~ 640 nm</td>
</tr>
<tr>
<td>Pulse width</td>
<td>40 ~ 90 ps</td>
</tr>
<tr>
<td>Repetition rate</td>
<td>20 ~ 80 MHz</td>
</tr>
</tbody>
</table>

### Spectrometer

#### Optical scheme

Czerny-Turner

#### Focal length

550 nm

#### Entrance slit

2 motorized crossed slits, independent control, width 0 ~ 2 mm

#### Exit ports

2

#### Motorized turret

with 3 gratings

#### Grating choice

150, 300, 600, 1200, 1800, 2400, 3600 G / mm, Echelle (75 G / mm)

<table>
<thead>
<tr>
<th>Grating (G / mm)</th>
<th>600</th>
<th>1800</th>
<th>75 (Echelle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range on CCD (nm)</td>
<td>75.5</td>
<td>21.4</td>
<td>4.8</td>
</tr>
<tr>
<td>(cm⁻¹)</td>
<td>2509</td>
<td>708</td>
<td>159</td>
</tr>
<tr>
<td>Dispersion (nm / pixel)</td>
<td>0.047</td>
<td>0.0134</td>
<td>0.0031</td>
</tr>
<tr>
<td>(cm⁻¹ / pixel)</td>
<td>1.55</td>
<td>0.44</td>
<td>0.1</td>
</tr>
</tbody>
</table>

*Under the following conditions:
1. Central wavelength 550 nm.
2. CCD pixel size 16 x 16 μm².
3. CCD width is 1500 pixels.

- Automatic spectra calibration: with built-in hollow cathode lamp.
- Granite base plate: for thermal and temporal stability

### Detectors

<p>| | |</p>
<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Cooled CCD (EMCCD) detector (main)</td>
<td>Maximum cooling: -100°C (water), -80°C (air)</td>
</tr>
<tr>
<td>DU970P EMCCD</td>
<td>High-end model with electron multiplying ability High speed 3MHz ADC. Recommended for high speed and high sensitivity measurement.</td>
</tr>
<tr>
<td>DU920P CCD</td>
<td>High speed 3MHz ADC. Recommended for high speed measurement.</td>
</tr>
<tr>
<td>DU401A CCD</td>
<td>100kHz ADC. Low cost model</td>
</tr>
</tbody>
</table>

#### Typical Quantum Efficiency (at 20°C) sample with new sating

![Typical Quantum Efficiency Graph](image)
● Cooled InGaAs array detector

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength range</td>
<td>800 nm ~ 2.2 µm</td>
</tr>
<tr>
<td>Active pixels</td>
<td>1024 × 1 (512 × 1)</td>
</tr>
<tr>
<td>Pixel size</td>
<td>25 × 250 µm²</td>
</tr>
<tr>
<td>Maximum cooling</td>
<td>−90°C (water), −70°C (air)</td>
</tr>
</tbody>
</table>

● APD (Avalanche Photo Diode): for photon counting or FLIM (Fluorescence Lifetime Imaging)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength range</td>
<td>350 ~ 900 nm</td>
</tr>
<tr>
<td>Timing resolution</td>
<td>40 ~ 60 ps</td>
</tr>
<tr>
<td>TE cooling</td>
<td>Yes</td>
</tr>
</tbody>
</table>

### Opto-Mechanics

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laser holder unit</td>
<td>With beam expander, laser line filter/retardation plate for original polarization orientation setting: max 3 pcs</td>
</tr>
<tr>
<td>Laser shutter/Spectrometer shutter</td>
<td>computer controlled</td>
</tr>
<tr>
<td>Motorized mechanism for excitation laser switch</td>
<td>YES</td>
</tr>
<tr>
<td>Motorized laser power control ND filter wheel</td>
<td>OD 0 ~ 6</td>
</tr>
<tr>
<td>Motorized beam expanders exchange wheel</td>
<td>4 positions</td>
</tr>
<tr>
<td>Excitation polarization cleaning</td>
<td>Glan Taylor prism</td>
</tr>
<tr>
<td>Motorized polarization orientation control</td>
<td>λ/2, 4 positions</td>
</tr>
<tr>
<td>Motorized edge-filter exchange</td>
<td>4 positions</td>
</tr>
<tr>
<td>Motorized polarization control in detection</td>
<td>Glan-Taylor prism</td>
</tr>
<tr>
<td>Motorized input-output mechanism</td>
<td>For Glan-Taylor prism</td>
</tr>
<tr>
<td>Motorized input-output mechanism</td>
<td>For hollow cathode calibration lamp</td>
</tr>
<tr>
<td>Motorized mechanism for focusing to pinhole objective change</td>
<td>3 positions for UV, VIS and NIR objectives</td>
</tr>
<tr>
<td>Motorized mirror for adjustment of Raman signal onto confocal pinhole</td>
<td>YES</td>
</tr>
<tr>
<td>Motorized mirror for adjustment of laser beam on sample</td>
<td>YES</td>
</tr>
<tr>
<td>Options for mirrors</td>
<td>coating, optimized for 350 ~ 1100 nm Al mirrors for 244 ~ 2300 nm range</td>
</tr>
</tbody>
</table>

### Scanners

<table>
<thead>
<tr>
<th>Scanner Component</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piezo-scanner (main)</td>
<td>100 µm (X-Y-Z) (optional 300 × 300 × 100 µm)</td>
</tr>
<tr>
<td>Closed-loop</td>
<td>Capacitive sensors</td>
</tr>
<tr>
<td>Resolution</td>
<td>5 nm</td>
</tr>
<tr>
<td>Repeatability</td>
<td>5 nm</td>
</tr>
<tr>
<td>Stepping motors</td>
<td></td>
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<tr>
<td>Scanning range</td>
<td>50 mm (X-Y)</td>
</tr>
<tr>
<td>Resolution</td>
<td>2 µm</td>
</tr>
<tr>
<td>Repeatability</td>
<td>2 µm</td>
</tr>
</tbody>
</table>
### AFM

<table>
<thead>
<tr>
<th>Measurement modes</th>
<th>SmartSPM™1000 with HE002</th>
<th>CombiScope™1000 with HE001</th>
<th>CombiScope™1000 with HE002</th>
</tr>
</thead>
<tbody>
<tr>
<td>· Compatible with simultaneous Raman</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>· Other modes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laser wavelength (for AFM feedback control)</td>
<td>1300 nm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scanning type</td>
<td>by sample</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control method</td>
<td>XYZ digital closed loop</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interface</td>
<td>USB 2.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laser alignment</td>
<td>Fully automated with 4 stepping motors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tip to sample approach</td>
<td>motorized, fully automated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fine Raman laser - SPM probe alignment</td>
<td>Microscope objective lens closed loop XYZ scanner X×Y×Z = 30×30×15 μm (±10%) (scanning angle depends on objective lens)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| For combined operation with microscope                                           |                          |                             |                             |
| Change microscope objective between low and high magnification with revolver     | **YES**                  |                             |                             |
| Max. microscope objective NA for combined AFM-Raman operation                     | 100×0.7                  | 100×1.4 Oil (bottom)        |                             |
| SPM head positioning (X×Y, mm)                                                   | Manual 12.7×12.7         | Motorized 1.6×1.6 mm       | Motorized 1.6×1.6 mm        |
| Sample size (X×Y×Z, mm)                                                          | 40×50×15                 | Standard microscope slide and cover glasses | 40×50×15 |
| Scanning range (X×Y×Z, μm)                                                       | 100×100×15               | 100×100×20                 | 100×100×20                 |
| Scanner Resonance frequency (unloaded, Hz)                                       | XY: 7000                 | XY: 450                    | XY: 450                    |
|                                                                                   | Z: 15000                 | Z: 1100                    | Z: 1100                     |
| Maximum scanning speed (line/sec.)                                                | 50*                      | 2                          | 2                          |
| Registration system noise (nm)                                                    | <0.1                     | <0.03                      | <0.1                       |
| Scanner noise (nm,rms)                                                           | XY:<0.1(Sens.ON)         | XY:<0.1(Sens.ON)           | XY:<0.1(Sens.ON)           |
|                                                                                   | <0.02(Sens.OFF)          | <0.02(Sens.OFF)           | <0.02(Sens.OFF)           |
|                                                                                   | Z:<0.04(Sens.ON)         | Z:<0.1(Sens.ON)            | Z:<0.1(Sens.ON)            |
| Operation in liquid                                                              | No                       | Yes (optional)             | No                         |

* With high resonance frequency (1.2 MHz) cantilevers; sample - HOPG, 8 μm scan size.
### 3Dsoftware
Advanced Nanofinder®HE software pack (Tokyo Instruments original)

<table>
<thead>
<tr>
<th>OS</th>
<th>Microsoft® Windows®7*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Languages support</td>
<td>Japanese, English, Chinese, Korean</td>
</tr>
<tr>
<td>Software Pack contents</td>
<td>Main Control and Analysis Nanofinder®HE program</td>
</tr>
<tr>
<td></td>
<td>&quot;FiPe®&quot; for spectral line with up to 5 Lorentzian or Gaussian curves fitting</td>
</tr>
<tr>
<td></td>
<td>&quot;Deconvolution&quot; for 1D or 2D data processing</td>
</tr>
<tr>
<td></td>
<td>AIST-NT SPM control software (in AFM combined configuration)</td>
</tr>
</tbody>
</table>

- **Control**
  - Control of all motors in Opto-Mechanics unit
  - Control of spectrometer ports, turret, wavelength
  - Control of spectral lamp with automatic calibration function
  - Control of all detectors and scanners (including AFM scanners)
  - Possibility to select mapping area directly on TV-CCD microscopic sample image
  - Simultaneous multidetectors readout during a single scan (including AFM topography and Raman spectroscopy)
  - Fast scanning algorithm

- **Analysis integrated**
  - **Measurements**
    - in point, 1D (scan along random line), 2D, 3D with full spectrum saving in every mapping point
  - **Spectral analysis with filtering**
    - base line correction, throughput normalization, Lorentzian or Gaussian fitting, spectra calculator
  - **Image display**
    - point measurement (including time dependence),
    - 1D, 2D, 3D: image rotation, magnification, arbitrary cross-sections
  - **Image manipulation with coloration, filtering, imaging functions variation**
    - integrated intensity of the spectral peak, peak position shift, line FWHM, fluorescence decay time for FLIM, etc., images calculator

### PC

<table>
<thead>
<tr>
<th>CPU</th>
<th>Intel core i7 equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory</td>
<td>4GB</td>
</tr>
<tr>
<td>HDD</td>
<td>500GB</td>
</tr>
<tr>
<td>Drive</td>
<td>Multi drive</td>
</tr>
<tr>
<td>Monitor</td>
<td>LCD 23 inch (AFM-Raman→2LCD)</td>
</tr>
</tbody>
</table>

### General

<table>
<thead>
<tr>
<th>Size</th>
<th>512(W)×1000(H)×1215(D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>240 kg</td>
</tr>
<tr>
<td>Optical table</td>
<td>1200×900 mm or 1500×1000 mm (for external He-Ne laser)</td>
</tr>
<tr>
<td>Computer rack</td>
<td>700×700 mm</td>
</tr>
<tr>
<td>Consumption power</td>
<td>Average 500 VA, Max 1500VA</td>
</tr>
</tbody>
</table>

### Measurement Features in Raman Microscopy
- All samples (solids and liquids)
- Non-destructive, non-contact measurements
- Measurement in standard ambient conditions
- No special sample preparation
- High spatial resolution
- Capability of 3D measurement for transparent samples
Nanofinder® HE main control and analysis program user interface

Typical applications in Raman spectroscopy

Chemical structure analysis
Strain&stress in crystal, doping effect, superlattice, lattice defect, chemical binding observation
Major samples: semiconductor, organic material, carbon nanotube, fullerene, diamond, jewel, oxide, various compound semiconductor, thin-film, L-B film, glass, liquid crystal, solar cell etc.

Foreign compound detection
Food, insoluble material in liquid, Si sample, photo mask, plastic, thin film, glass inside etc.

Crystal structure analysis
Crystal layer change, crystallization, amorphous crystallization

Erosion evaluation
Oxidization detection of various metal samples like stainless steel

Investigation & research on coloring, discolored
Photochromic material, functional group identification, painting inspection

Reaction process monitoring (Production process control)
Reaction of polymerization, dissociation, chemical&catalytic reaction, diffusion, melting

Archeology
Ancient potter, glass, paint

Security
Detection&inspection of faked print, counterfeit, drug, chemicals

Biotechnology & medical
Detection of blood serum, indifferent cell, tumor, analysis&diagnosis of bone quality, bone cell, skin change, viable yeast, protein