Determination of the Average Aspect ratio of Gold Nanorods (GNRs) using UH4150 UV-VIS-NIR Spectrophotometer

INTRODUCTION

Au nanorods are rod-shaped gold nano-particles. Since the shape of the rods (aspect ratio) controls the light absorption specificities, their application is currently under development to manufacture gold-particles to probe DNA or optical memory materials.
Normally the aspect ratios of Au nanorods are determined by image-measurement using the transmission electron microscope (TEM). However, the aspect ratios of rods can easily be determined by measuring the peak location of the surface plasmon bands originating from the major-axis at around 900 nm.[1)] (Au nanorods have 2 surface plasmon bands along the major- and minor-axes originating from surface plasmon oscillation, as opposed to Au nano-particles that normally have only one surface plasmon band at around 520 nm. The absorption of Au nanorods is at around 520 nm for minor-axis and 900 nm for major-axis.) Peak location is derived from formula 1 based on the aspect ratio (R) of Au nanorods. Formula 2 will be obtained by solving formula 1 for the aspect ratio (R).
In this study, the aspect ratios were calculated from the absorption spectrum of Au nanorods using the UH4150 Spectrophotometer and in comparison with the values obtained from TEM images.
1) S. Link, M. A. El-Sayed, *J. Phys. Chem,* Vol.109, No.20, 10531 (2005)

ANALYTICAL CONDITIONS

Instrument: UH4150
(Direct light detection system)
Wavelength : 250 - 1350 nm
Slit : 2 nm
Sampling Intervals: 0.5 nm
Scan Speed : UV-VIS 120 nm/min
NIR 150 nm/min

SAMPLE

Sample: Au nanorods (Au-W4)
Dai Nippon Toryo Co., Ltd.
(Manufacturer's reference value)
Average Aspect Ratio: approx. 5
Average Minor-axis Length
: approx. 10 nm
Average Major-axis Length
: approx. 50 nm

MEASUREMENT RESULTS

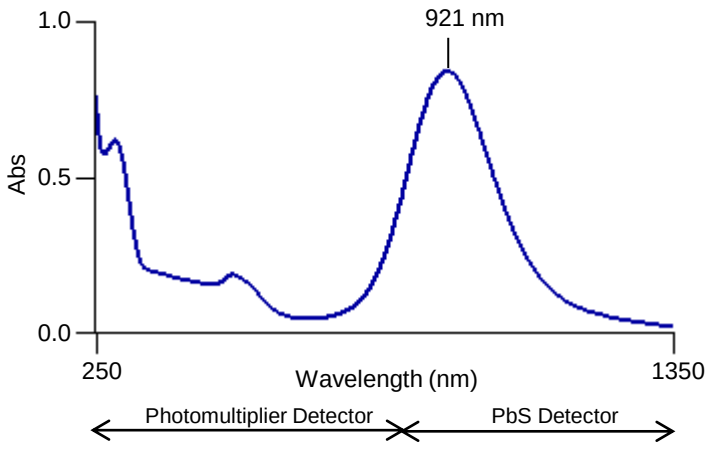

Figure 1. Absorption spectrum of Au nanorods

FORMULA AND CALCULATED RESULTS

[Formula]

$\lambda_{max} = (53.71 \cdot R - 42.29) \cdot \varepsilon_m + 495.14$ (Formula 1)

$$R = \frac{\lambda_{max} - 495.14}{53.71 \cdot \varepsilon_m} + 0.79 \quad \text{(Formula 2)}$$

$\varepsilon_m = 1.77$ for water

[Measurement results from 3 samples]
Absorption Peak Wavelength: 921 ± 1.5 nm
Aspect Ratio (R): 5.27 ± 0.2

Features of UH4150-model

○ Suppressed unevenness due to the detector change
Au nanorods have an absorption maximum at around 850 nm, with a photomultiplier detector for the ultraviolet-visible region and a PbS detector for the near-infrared region switch. General spectrophotometers show unevenness of readings due to this detector switch, however, the rigorous optical design and the zero correction of the detectors in the UH4150-model enables to obtain data with minimum unevenness of readings due to the detector change.
○ Wavelength accuracy and measurement reproducibility
Since the aspect ratios of Au nanorods are calculated based on the wavelength of absorption maxima, accurate wavelength determination is critical. The UH4150-model has a wavelength accuracy of ± 0.2 nm, which provides accurate measurements of aspect ratios of Au nanorods with high reproducibility.

KEY WORDS
Material/Processing Material Related,
Other Material/Processing Material Related, Au Nanorod, Aspect ratio,
Absorption Spectrum, UV, NIR, UH4150

Spectrophotometer (UV)

Sheet No. UV130002-01

Measurement of the Average Aspect ratio of Gold Nanorods (GNRs) Using the HT7700 Transmission Electron Microscope

MEASUREMENT CONDITIONS

Instrument : Hitachi Transmission Electron Microscope T7700
Accelerating Voltage : 100 kV
Observation Magnification : 50000-fold
Measurement Software : WinRoof Ver.7.0 (Mitani Corporation)

MEASUREMENT PROCEDURES

[Aspect ratio measurement procedure]
Aspect ratio was measured by using image processing/image measurement software WinRoof Ver. 7.0, as follows.

(1) Specify the measurement range
(2) Image processing such as horizontal correction and median
(3) Binarization (Processing with 2 threshold values)
(4) Shape-specific measurement (Calculate the ratio of the needle-like shape)

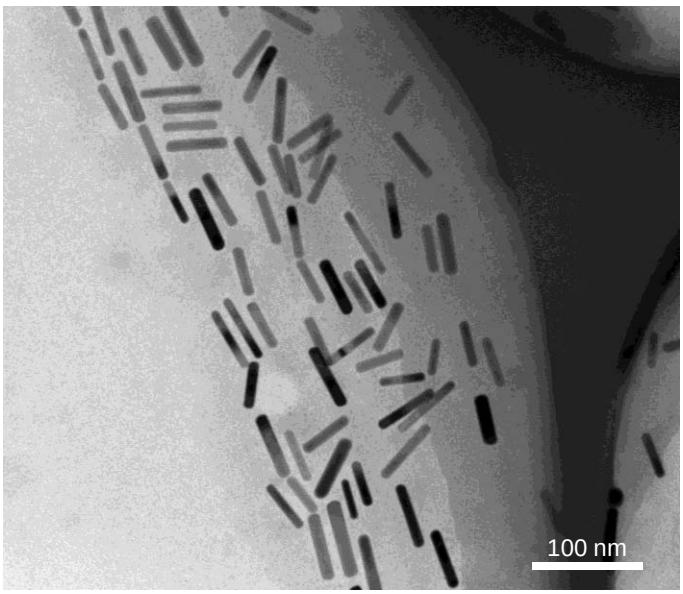

Figure 2. TEM image of Au nanorods

[Measurement result by TEM(N = 40)]
Aspect Ratio (R): 4.83 ± 0.63

Measured aspect ratio from the TEM image analysis was 4.83 ± 0.63. This value is within the range of error of 5.27 ± 0.2 obtained from the absorption spectrum of the spectrophotometer. TEM image can be directly measured from the shape of the Au nanorods.
On the other hand, the calculated value from the absorption spectrum is suited for easily capturing the average aspect ratio of the Au nanorods.

KEY WORDS
Material/Processing Material Related,
Other Material/Processing Material Related, Au Nanorod, Aspect ratio,
Image measurement, Transmission Electron Microscope, Gold Nanorod,
Au Nanorod, Aspect ratio, HT7700

Spectrophotometer (UV)

Sheet No. UV130002-02