Near-field absorption imaging by two color nano-light source

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1. Introduction

Aperture-less near-field scanning optical microscopy (NSOM) is a promising spectroscopic technique for nano-scale imaging which provides high spatial resolution beyond the diffraction limit of light. Due to its advantages, aperture-less NSOM has been employed for various spectroscopic applications, for example, absorption and scattering for electron state analysis by monitoring the Rayleigh scattering efficiency; or vibrational state analysis by measuring Raman scattering from molecules. However, absorption analysis via monitoring Rayleigh scattering is not straightforward since the origin of Rayleigh scattering is a complex problem. This is because the background signal of Rayleigh scattering from the substrate and the optics cannot be distinguished from the signal coming from the sample.

In this study, we propose a novel method for absorption imaging based on aperture-less NSOM using Raman-nano-light, whose origin, unlike Rayleigh scattering, is clearly known.

2. Experimental and Results

We utilized an uncoated silicon nano-tip as the near-field probe, which creates a strong Raman signal of silicon at the tip apex [1]. When the nano-tip is placed on the sample and is illuminated, it generates silicon Raman signal of nanometer size, which, while passing through the sample, can be partially absorbed by the sample. Therefore, one can measure the absorption of the silicon Raman signal by measuring the intensity of transmitted light through the sample at nano-scale resolution. Further, we employed two excitation lasers with wavelengths of 488nm and 594nm, in order to observe the absorption property of the sample independent of the sample topography. The wavelength of Raman nano-light of silicon is shifted by 520cm^{-1} and appears at 502nm and 613nm, respectively, for the two incident wavelengths. Eventually, we obtained an absorption ratio image (A_{613nm}/A_{502nm}) constructed by the intensity ratio of Raman signal of silicon excited by the two incident lasers, which reflects absorption coefficient of the sample. To verify the success of absorption imaging, we observed two types of carbon nanotubes (CNTs) that have different absorption properties. Figure 1(a) shows an AFM image of metallic and semiconducting CNTs. An absorption ratio image (A_{613nm}/A_{502nm}) allowed us to distinguish the two kinds of CNTs in Figure 1-b, due to the difference of their absorption coefficients. Because an uncoated silicon nano-tip was employed in this measurement, we achieved a spatial resolution of 18nm corresponding to the size of the tip apex, which was confirmed by the line-profile of absorption ratio along the white dotted line in Figure 1(b).

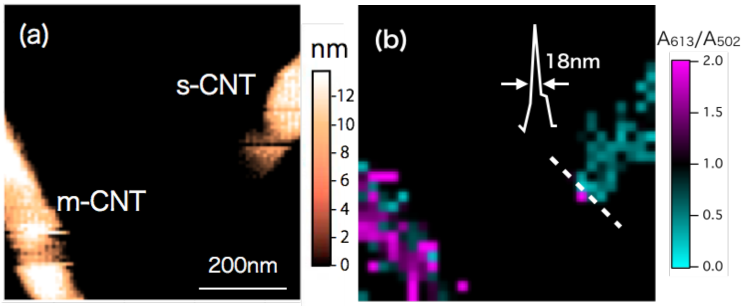

Fig. 1: (a) An AFM image of two types of CNTs (b) An absorption ratio (A_{613nm}/A_{502nm}) image constructed by the intensity ratio of the Raman signal of silicon excited by two color lasers. The inset shows a line-profile of absorption ratio is shown in figure 1-b along the white dotted line.

3. Outlook

Since this new nano-scale imaging is based on a platform of conventional aperture-less NSOM, we can develop this technique for further spectroscopic analysis, such as for Rayleigh scattering and Raman spectroscopy. The combination of near-field absorption and Raman analysis would provide a new perspective for nano-scale analysis of both electronic and vibrational properties of various materials.

References

[1] Y. Saito, P. Verma, K. Masui, Y. Inouye and S. Kawata *J. Raman Spectrosc*. **40**, 1434 (2009)

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