Near-field optical microscopy and its recent advances: high-speed imaging and broadband measurements

Dr. Takuyuki Umakoshi
(Osaka University, Department of Applied Physics)

Abstract

Near-field optical microscopy (aperture-less type) enables optical analysis and imaging with the nanoscale spatial resolution owing to light field localized at a nanometric volume at a plasmonic tip apex. It has been recognized as a powerful analytical technique for a few decades since its invention, and has still shown tremendous progress, contributing to a wide variety of scientific fields. Its spatial resolution, for example, has been drastically improved in recent years, which now goes down to the single molecular level.

In this talk, we introduce some unique aspects of the near-field optical microscopy through developments that we recently made in this technique. Focusing on not spatial resolution but temporal resolution, we demonstrated high-speed near-field optical imaging [1]. The imaging speed is mostly limited by slow scanning of either a tip or a sample, which usually takes several minutes to take an image at least. By introducing the high-speed atomic force microscope technique, we achieved near-field fluorescent imaging within a few seconds. Furthermore, we developed a plasmon nanofocusing technique to extend the spectral range in the near-field optical microscopy [2]. Because near-field light is often generated through plasmonic resonant oscillation at a metallic tip, in addition to some technical difficulties, the spectral range is limited within a certain width around the plasmon resonance wavelength. We created broadband near-field light at a metallic tip through plasmon nanofocusing, which is based on propagation, not resonance, of plasmons. We further exploited it for super-resolution scattering spectral imaging of carbon nanotubes.

We have been continuing for further developments. At the end of the talk, we will discuss future perspective of these techniques.

Reference

[1] T. Umakoshi et al., *BBA General Subjects*, **1864**, 129325 (2020).

[2] T. Umakoshi et al., *Science Advances*, **6(23)**, eaba4179 (2020).