White nano-light-source via plasmon nanofocusing for NSOM

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1. Introduction

A white nano-light-source is an appealing light source that enables us to measure the broadband optical response from a sample at a nano-scale. Generally, nano-light-sources are induced through plasmon resonance by irradiating the apex of a nano-size metal probe, which generates near-field light. Although it has been applied for near-field optical microscopy, it can only be generated for certain wavelength, because it is a resonance phenomenon. Therefore, it is very difficult to generate a broadband near-field-light. Furthermore, in the case of general NSOM, one needs to use lock-in detection due to huge scattering noise caused by incident laser, which also prevents broadband spectroscopic detection.

2. Experimental and Results

Plasmon nanofocusing is a phenomenon, where surface plasmon polaritons propagates on a tapered metal tip toward the apex and drastically slow down at the apex, which results in the generation of a strongly confined and enhanced near-field light at the apex [1]. By using this focusing process, background free measurement without lock-in detection has been achieved, since incident light irradiates far from the tip apex. Furthermore, focusing process does not depend on wavelength because it is not a resonance phenomenon, so any wavelength can be focused at the apex. That is why a broadband nanofocusing can be realized. Usually, gratings are used as plasmon coupler, which work for a certain wavelength. Here, we applied a single slit for plasmon coupler for white light, which can be considered as superposition of multiple wavelength. A SEM image of a fabricated tip is shown in Fig. 1(a). First, a silver thin and smooth film was evaporated on an oxidized silicon tip. Then, a 200 nm single slit was milled 8 μm away from the tip apex using FIB milling. When the slit on the tip was illuminated with a broadband supercontinuum laser having a polarization perpendicular to the slit, we observed a bright spot at the apex, as shown in the yellow circle in Fig. 1(b). By changing polarization of the incident light, we confirmed that a bright spot at the apex was caused through plasmon nanofocusing, because plasmon coupling does not occur when polarization direction is parallel to the slit. Besides, we measured scattering spectra from the tip apex (Fig. 1(c)) which shows broadband wavelength range of near-field light at the apex and confirms the generation of white nano-light at the tip apex. Finally, we applied the created white nano-light-source for NSOM measurement, which showed broadband response from the s-CNT and m-CNT with high spatial resolution.

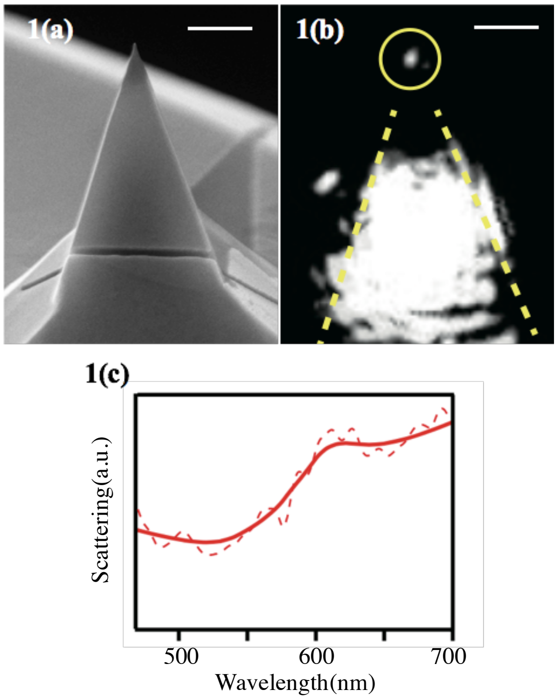

Fig. 1(a) SEM image of fabricated tip. The distance between the slit and the tip apex is 8 μm and the slit width is 200 nm. The scale bar represents 2 μm. (b) The large white spot shows irradiating spot of incident light, and the small spot in a yellow circle shows a nanofocused spot at the tip apex. Yellow dashed line shows the shape of the tip. (c) This figure shows scattering spectrum from the tip apex, depicting the nano-light spot at the tip apex, which is shown in the yellow circle in (b), consists a broad wavelength regime.

3. Conclusions

A white nano-light-source was created at the tip apex via plasmon nanofocusing. We will show broadband near-field scattering analysis by using fabricated tip.

References

[1] M. Stockman, *Phys. Rev. Lett.* **93**, 13, (2004).