Noncontact-AFM-based scanning near-field optical microscopy

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Scattering-type scanning near-field optical microscopy (sSNOM) is an exceptional tool for visualizing the dielectric optical response of sample surfaces. The near-field signal detection is typically conducted by lock-in referring to silicon cantilever tapping. However, the operation based on tapping-mode atomic force microscopy (AFM) limits the spatial resolution of sSNOM to approximately 10 nm [1]. In this study, we demonstrate high-resolution sSNOM using a qPlus-sensor-based noncontact-mode AFM (ncAFM) under low temperature and ultrahigh vacuum conditions [2]. The stable cantilever oscillation with 1-nm amplitude, which is lower than that for tapping AFM, allows for the sensitive detection of the near-field localized at the plasmonic Ag-tip–Ag-sample junction under visible laser illumination (Fig. 1a). With a Si/A(111) sample (Fig. 1b), we obtained a sSNOM image reflecting the material contrast between Si and Ag (Fig. 1e) simultaneously with STM (Fig. 1c) and ncAFM (Fig.1d) images, achieving a spatial resolution of 1 nm. The effective combination of ncAFM with sSNOM has high potential for optical response imaging of single molecules and atoms.

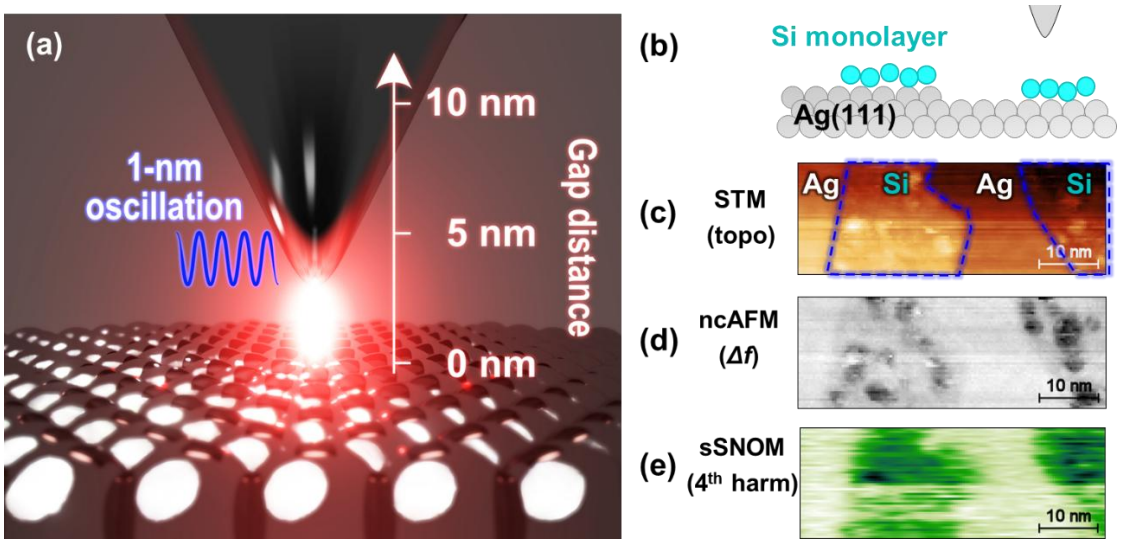

Figure 1. (a) Concept of ncAFM-based sSNOM. (b) Side-view scheme of the Si/Ag(111) sample. (c–e) Simultaneously acquired image of STM (c), frequency shift (d), and the 4th harmonic lock-in signal of the scattering light (e).

Reference

[1] X. Chen, et al., Adv. Mater. **31**, 1804774 (2019).

[2] A. Shiotari et al., Sci. Adv., accepted (2025); DOI: 10.1126/sciadv.adu1415