パッシブ近接場顕微計測に対する探針配置の影響

Important role of tip configuration in a passive near-field microscope

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In the passive THz scattering-type scanning near-field microscope (s-SNOM), electromagnetic (EM) evanescent waves generated in the near field of a sample material are scattered by a sharp metal tip and the scattered waves entering the light cone of the objective of a THz microscope (insets of Figs. 1 (a) and 1(b)) are detected [1-3]. For these passive measurements, it is essential that the metal tip senses the evanescent waves generated by the sample but is unaffected by the external radiation incident on the tip.

We report here that a careful attention has to be paid to assure the necessary condition mentioned in the above. We study two configurations of the near-field optics (detection wavelength: 14.1 μm): One setup is shown in the inset of Fig.1 (a), where a quartz tuning fork (TF) supporting the tip is set outside the light cone of the objective, while in the other setup shown in the inset of Fig. 1 (b) an edge of the TF hinders a part of the light cone of the objective. We study decay profiles of the passive near-field signal with increasing the tip-height h. The signal rapidly decays with increasing h with a decay profile substantially kept unchanged at elevated temperatures in configuration (a), but a long tail component appears in the decay profile at elevated temperatures in configuration (b). Theory predicts that the decay profile is kept unchanged at elevated temperatures. So it is concluded that the NF signals obtained in configuration (b) contain artifacts, which are not attributed to thermal evanescent waves of the sample. Supposedly, spontaneous emission from the sample (Plank's far-field radiation) is intensified at elevated temperatures and illuminates the tip due to reflection at the backside of the TF. Aside from the interpretation, these experimental results definitely indicate that the tip unit should be placed outside the light cone of the objective for reliable passive microscopy measurements.

It should be mentioned that configuration (b) was applied in a different group, and experimental results different from those of our experiments were reported [4]. Configuration (a) was applied in all of our previous work [1-3] so that our work has been free from artifact components.

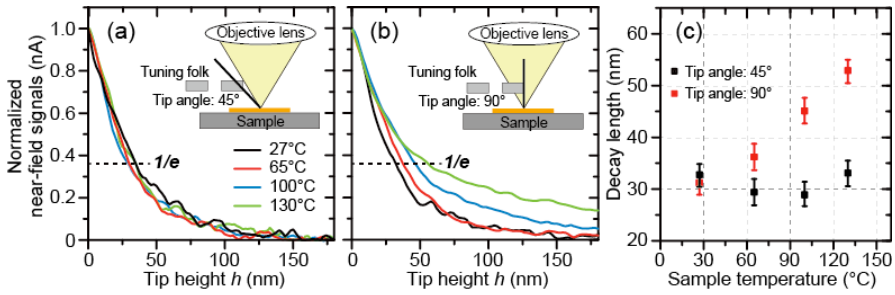

Fig. 1 Decay profiles of the passively detected NF signals on a Au film, studied in two different configurations. The yellow triangles in the insets of (a) and (b) show the light cone of the objective of the microscope. (a) No hindrance in the light cone of the objective. (b) The TF edge hinders the cone of NA. The long decay profile at elevated temperatures shows that an obstacle in the light cone spoils the passive measurements. (c) Characteristic decay length of the NF signal against sample temperature.

Reference:

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