Hot spots in atomic force microscopy

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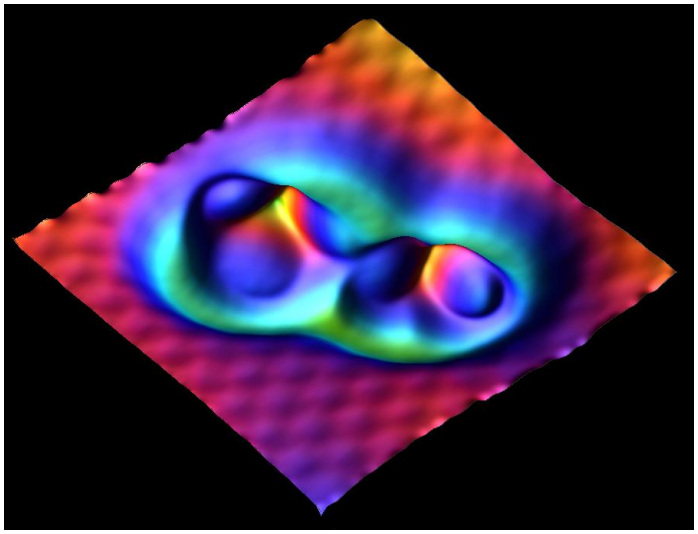
Atomic force microscopy (AFM) and scanning tunneling microscopy (STM) image surfaces with atomic resolution and enable local spectroscopy of current versus voltage, forces and dissipation. The qPlus force sensor [1] combines STM and AFM capability, enabling highly precise imaging and spectroscopy functions and measuring the forces that act during atomic manipulation [2]. While STM had better spatial resolution than AFM in the past, the situation is reversed now with modern AFM [3]. Angular dependencies of chemical bonding forces have been observed before for Si tips interacting with Si surfaces [4], W tips interacting with graphite [5] and similarities exist between metal tips interacting with CO molecules on Cu and Si adatoms [6]. In the latter two cases, light atoms such as carbon or oxygen interacted with much heavier and much larger metal atoms. Gross et al. established that CO is an excellent probe for organic molecules. For example, pentacene can be imaged at excellent resolution with CO terminated tips [7], although the softness of CO on tips can lead to image distortions [8,9]. Tips made of permanent magnets such as CoSm allow to resolve the spin order in the antiferromagnetic insulator nickel oxide [10]. The stiff cantilever/small amplitude technique used here also allows true atomic resolution in ambient conditions [11], and small iron clusters on Cu (111) are resolved by force microscopy [12]. In summary, we see three hot spots in modern AFM development: excelling in spatial resolution, force resolution and overcoming environmental operational limits.



AFM image of a Fe trimer next to a Fe dimer on Cu(111) [12].

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