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Resonant Probe AFM: Uses and Advantages

RESONANT PROBE ATOMIC FORCE MICROSCOPES' UNIQUE CONSTRUCTION AND FUNCTIONALITY ENABLE THEM TO SERVE IN APPLICATIONS DEMANDING HIGH-ON ACCURACY, RESOLUTION, AND EXCEPTIONAL HIGH-SPEED

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A resonant probe atomic force microscope (AFM) offers capabilities and benefits not found in commonly used optical deflection AFMs in the measurement of physical constants, physical properties, and surface morphology.

However, resonant probe AFMs' functionality and potential remain relatively unknown, even though resonant probe technology and its methodology are decades old. This article discusses resonant probe AFM construction, functionality, and typical applications, as well as introduces readers to MadCity Labs' custom AFM solutions.

Resonant Probe Construction and Functionality

The basis for resonant probe microscopy — and its key differentiator from optical deflection approaches — is a piece of quartz crystal shaped like a tuning fork.

The technology was developed and leveraged by Zeiss in the 1990s as an excitation that would vibrate at a specified frequency, very accurately. The technology was applied by Zeiss to transceivers, and later it was integrated into microprocessors to guide their "line of clay" courses.

In the 1980s, IBM Research developed resonant probe microscopy using these crystal quartz tuning forks at its Armonk Research Lab in Silicon Valley. Under this technique, the tuning fork — with tips made of various materials applied to the end, depending on the application — is used as a force sensor.

The fundamental difference between the optical deflection technique and the resonant probe technique is that the resonant probe always is oscillating when operating. It is always in intermittent contact with the surface. Optical deflection systems were initially envisioned only as constant contact probes, wherein you drag the probe across a surface, observe any oscillation, and you can measure how it moves (e.g., measuring frictional forces on a surface). This self-intermittent contact probing was developed later for optical deflection AFMs.

Because of the extent to which resonant probe microscopy allows improvements to modify and customize probe tips, it tends to attract individuals and teams who require customization and the flexibility to make their own tips.



At the advent of commercial AFM microscopy early 1990s, readers need to produce standardized more standard tips — essentially, small cantilevers wherein you shine a laser onto the back of the tip, place that on a position sensor detector, and then measure the deflection of that tip. While the methodology has dominated the market since, the tuning fork has emerged as a reliable, agile microscopy tool.

For example, attaching a standard commercial optical deflection tip to the tuning fork allows it to be used for both optical deflection and resonant probe microscopy. A wire glued to the end of the probe could be used in one of two ways: as a conductive needle for direct imaging, and the wire tip could be used as a near-field probe; or, one could apply a bias voltage to the tip.

Resonant Probe AFM: Uses and Advantages

A resonant probe atomic force microscope (AFM) offers capabilities and benefits not found in commonly used optical deflection AFMs in the measurement of physical constants, physical properties, and surface morphology. This article discusses resonant probe AFM construction, functionality. Some of the applications particularly well suited to resonant probe AFM are optical antenna properties, quantum materials (NV center research), and terahertz microscopy/spectroscopy.

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