letters

STM not developed in a vacuum

Calvin Quate's article "Vacuum tunneling: A new technique for microscopy" (August, page 26) properly calls attention to a developing technology that promises new and more detailed knowledge on an atomic level of the physical and electronic properties of surfaces. [See the news story on page 17.] Sadly, the article contains historical inaccuracies, distortions and omissions that will help perpetuate the public's ignorance of the actual evolution of the scanning tunneling microscope.

It is only recently that the pioneering work of Russell Young at the National Bureau of Standards throughout the late 1960s and early 1970s has begun to gain a bit of the recognition it so justly deserves. Unfortunately, Quate's article fails to reflect the realities accurately. Two quotes illustrate the point: "The scanning tunneling microscope had its beginnings in Frankfurt in 1978, in a conversation betwen [Heinrich] Rohrer and [Gerd] Binnig," and "Young discussed vacuum tunneling in his PHYSICS TODAY article [November 1971, page 42], but did not pursue the subject in his technical publications." In fact, two fundamental papers published by Young (*Physical Review Letters* **27**, 922, 1971, and *Review of Scientific Instruments* **43**, 999, 1972) invalidate both of these claims. Neither paper was referred to by Quate.

The *RSI* article reported topographic maps of a diffraction grating replica, obtained using an instrument essentially identical to the present-day STM. The *Physical Review* letter reported the first vacuum tunneling measurements, made using this same instrument. (Quate seems to have inverted the roles of Young and Clayton Teague, who came to NBS to do a doctoral thesis with Young using Young's instrument.) Both the NBS instrument, called the "topografiner," and the STM employ two orthogonal piezoelectric elements to scan in a raster a sharp emitter above a conducting surface while a third, z piezo follows the profile of the surface. Both instruments amplify and feed back to the z piezo the current changes at fixed emitter voltage (or voltage changes at fixed emitter current) so that the emitter is scanned at a constant distance above the surface. The z piezo voltage is then a measure of the surface topography. Both the topografiner and the early STM papers predicted sub-angstrom vertical resolution and 50–100-Å horizontal resolution, depending on the emitter radius.

The topografiner reported in 1972 was a prototype instrument with elementary vibration control and no provision for repositioning the specimen. Although excessive vibration prevented scanning in the tunneling mode, static current versus voltage curves for several fixed spacings were reported that displayed, as the spacing was decreased, the evolution from field-emission tunneling to the linear current–voltage characteristic required to verify metal–vacuum–metal tunneling. Many of us associated with Young at the time were extremely disappointed when in 1972 the development of the instrument was terminated by a management decision to redirect effort into a new program in micromeasurements in response to the calibration needs of the microcircuit industry.

All of the above is in no way intended to minimize the outstanding contributions of Binnig and Rohrer, who first demonstrated atomic resolution in a scanning device and who went on to apply the instrument to a number of significant surface problems.

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SDI: Subs, space and smuggling

In defending his book *How to Make Nuclear Weapons Obsolete*, Robert Jastrow (January 1986, page 9) notes that all of Richard Garwin's errors are in one direction—they make strategic defense against Soviet missiles seem costly and ineffective. No one can make