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# Point-Projection Microscopy

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The history of Point-Projection Microscopy can be traced to 1928 when tunneling electrons were extracted from the tip of a needle-like cathode at room temperature and projected several centimeters to an anode in high vacuum [1-2]. In 1937 Erwin Wilhelm Müller coated the anode of a similar apparatus with a phosphor screen to image the emitted electrons and the Field Emission Microscope was born [3]. The Point-Projection Microscope is unique because its image magnification (typically $10^5$ -$10^6$) is created by a highly divergent electrostatic field at the tip apex, with the result that the magnification is easily changed by changing the electrode separation and the image is not influenced by external vibration.

In 1951 Erwin Müller introduced hydrogen into a Field Emission Microscope at a pressure of several millitorr and reversed the electrode polarity in the hope of improving the image resolution by creating hydrogen ions in the high electric field at the tip apex. It worked and the Field Ion Microscope was born although individual atoms in the image could not be resolved (Figure 1) [4]. In 1956 Erwin Müller and Kanwar Bahadur introduced helium into a Field Ion Microscope and obtained the first images of single atoms on a tungsten surface at room temperature [5]. In the same year Erwin Müller reported that cooling the tip to cryogenic temperatures greatly improved the image resolution [6]. Atomic resolution had been achieved but the identity of the imaged atoms could not be determined. That problem was finally resolved in 1967 when Erwin Müller and John Panitz introduced the Atom-Probe Field Ion Microscope (Figure 2) [7]. The Atom-Probe Field Ion Microscope was; and remains, the only instrument that can determine "the nature of one single atom seen on a metal surface and selected from neighboring atoms at the discretion of the observer" [8].

In 1973 J. A. Panitz introduced the 10 cm Atom Probe [9]. Patented in 1975 as the Field Desorption Spectrometer and dubbed the Imaging Atom-Probe, it allowed individual atoms to be identified and imaged as a function of depth from the surface; thereby becoming the first 3-D Atom Probe [10]. In 1982 he used the Imaging Atom-Probe to obtain the first tomographic images of biomolecules on a metal surface (Figure 3) [11] Today, the Atom .Probe has emerged as an important tool in the arsenal of tools used to develop new materials for technology and industry [12]. As Atom Probe technology advances new vistas of exploration will emerge, continuing the unique legacy of the Point-Projection Microscope.

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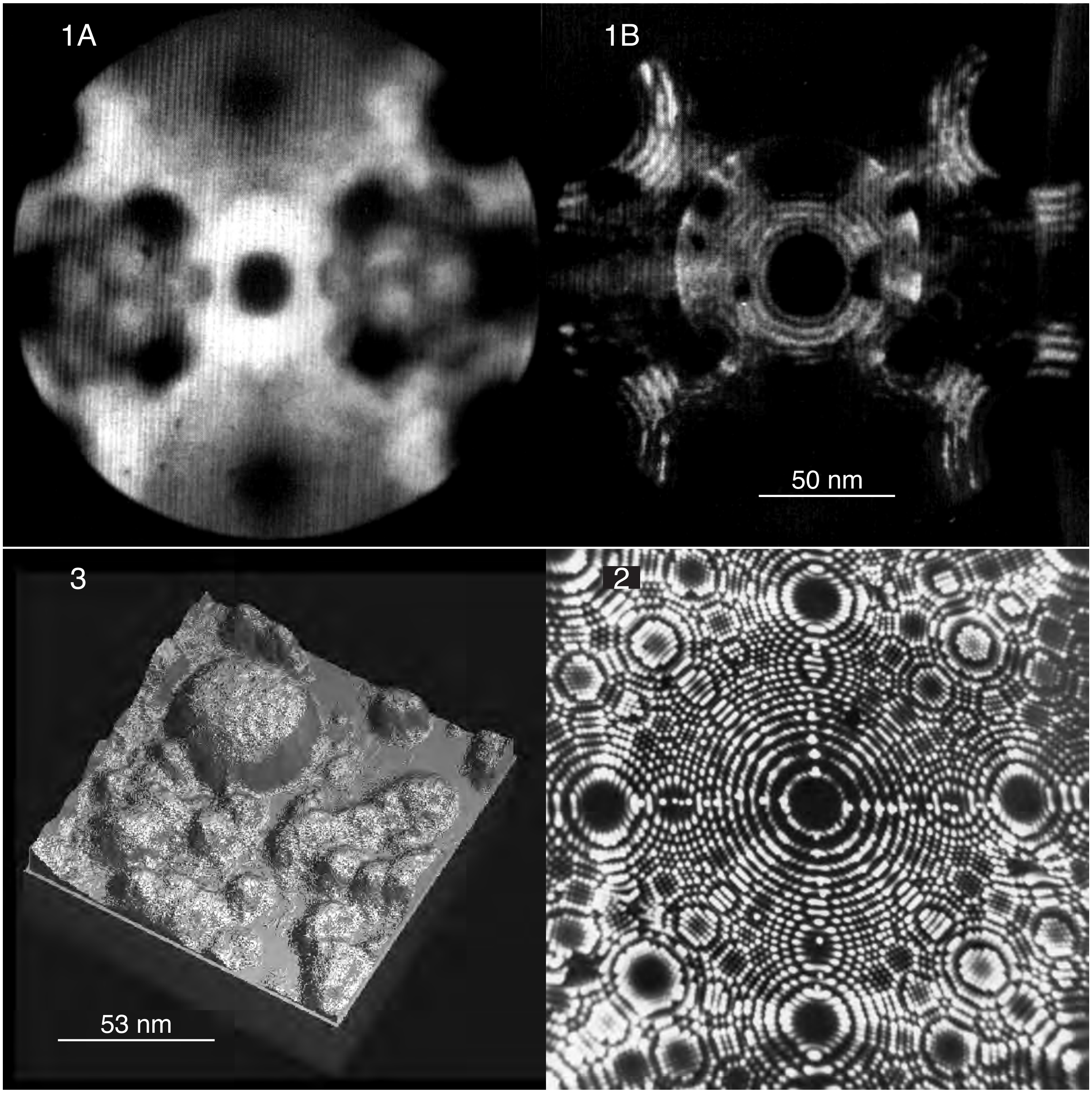


**Figure 1.** (A) A room-temperature field-electron-emission image and (B) a field ion image of the same tungsten tip taken by E. W. Müller in 1951. See Reference 4. **Figure 2.** Helium field ion image of Iridium at 30K taken in the first Atom-Probe Field Ion Microscope. See: John A. Panitz. The Atom Probe FIM. Ph.D. Thesis, (University Park, PA 1969) 31 (http://panitz.unm.edu). **Figure 3.** Tomographic image of an unstained ferritin monolayer on the apex of a tungsten tip. See Reference 11 and W. O. Saxton, Ultramicroscopy 16 (1985) 387 for details of the reconstruction algorithm.

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