

Ballistic-Electron-Emission Microscopy of Device Materials and Structures

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Over the past two decades, scanning tunneling microscopy (STM) has revolutionized surface science by providing the capability for real-space, atomic-resolution imaging and spectroscopy of surfaces. This capability derives from the implementation of vacuum tunneling in STM, and from the exponential decay of tunneling probability with increasing vacuum gap. Because of this, information derived from STM experiments reflects primarily surface or very-near-surface properties.

Ballistic-electron-emission microscopy (BEEM) uses STM to probe subsurface electronic properties of thin films and interfaces. By taking advantage of the STM tip as an injector of energetic electrons, a highly directional distribution of hot electrons is deposited into a sample structure. Since scattering lengths in metals and semiconductors are usually several nanometers, and in some cases as long as tens of nanometers, these electrons can be used as a nondestructive probe of subsurface properties, such as interface barrier heights and electron scattering processes. BEEM probes at energies within several electron volts of the Fermi level, a range of direct interest to device operation. In addition, the extremely local electron injection by STM allows nanometer-scale resolution of device properties, of great interest as device dimensions continue to shrink.

This talk will provide an overview of BEEM applications to problems of interest for electronic devices and survey some of the results of current investigations. Areas of particular interest at JPL and NASA will be discussed.