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This Week's Citation Classic

Madey T E & Yates J T Jr. Electron-stimulated desorption as a tool for studies of chemisorption: a review. *J. Vac. Sci. Technol.* **8**:525-55, 1971. [National Bureau of Standards, Washington, DC]

Bombardment of solids by low energy electrons can cause various changes in the surface region particularly if the surface contains a chemisorbed layer. This is termed electron stimulated desorption (ESD) and the nature of this phenomenon is reviewed from an experimental and theoretical viewpoint. [The *SCI*® indicates that this paper has been cited over 120 times since 1971.]

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"By early 1970, the use of electron stimulated desorption (ESD) had proven to be a useful method for characterizing the nature of adsorbed species on surfaces. The phenomenon had first been quantitatively characterized by Paul Redhead at the National Research Council, Canada, in 1964, who had studied its influence on pressure measurements made with a Bayard-Alpert ionization gauge.[1] Independently in 1964, Dietrich Menzel and Robert Comer at the University of Chicago had extensively studied the phenomenon using field electron emission.[2] In the six-year period between the first quantitative studies of the phenomenon and our review, approximately 150 research papers had been written. We (then young researchers in the field) were quite flattered when Redhead, editor of the *journal of Vacuum Science and Technology,* asked us to write a definitive review of the emerging area concerned with ESD. We surveyed the state of the field, discussed the existing theory and some representative experimental results, and wrote up a comprehensive bibliography outlining all of the work with which we were familiar. John Yates was spending a year at the University *of* East Anglia in England, funded by the Training Act to study infrared spectroscopy applied to adsorb molecules at surfaces, and he wrote the application section including the comprehensive bibliography. I was at the National Bureau of Standards in Washington and wrote the introduction and the survey of experiment and theory. The final review was put together via transatlantic mail (despite British mail strikes which required us to rely on APO services from US forces in Britain). The line drawings were permanently lost once in the mailing from Britain and had to be rephotographed in the US.

"The resulting article has been well received in the scientific and technological community. Redhead wrote soon afterward that he thought the article was a classic one; to this we replied that had we known that we would have written it in Latin!

"Why, indeed, has the review been cited as a Citation Classic? Several reasons may account for its popularity and utility. Firstly, there are a number of experimental methods which rely upon electron bombardment of surfaces for study. These include low energy electron diffraction, Auger spectroscopy, and electron microscopy. All of these electron impact methods are plagued by the influence of the electron beam on the surface being studied. The influence *of* the electron beam on the surface just cannot be ignored as was often done previously. Secondly, the influence of the electron beam on adsorbed species on surfaces has been shown to be a powerful tool for studying the adsorbed species themselves, and at the time of our review this was just being recognized by ourselves and several other groups. Thirdly, the technology of electron beam lithography has become important in semiconductor device processing and the general principles in our article are applicable to this area.

"We were fortunate to be in a position to write a review article in a field which was just opening up (and which still is a dynamic area of surface investigation). Our review is still a timely account of the principles involved in ESD and its bibliographic content is still a useful review of the early work. New developments in the field include the NBS-discovered sharp angular distribution of positive ions from adsorbates on single crystals.[3] These angular distributions are directly related to the orientation of the adsorbate molecules on their atomic binding sites. In addition, recent efforts to improve the theory of the electron-excited dissociation of surface species are currently originating from several different research groups.[4] Thus, the field still progresses rapidly in ways which were unexpected back in 1971 when our review was written."

1. **Redhead P A.** Interaction of slow electrons with chemisorbed oxygen. *Can. J. Phys.* **42**:886-905, 1964.
2. **Menzel D & Gomer R.** Desorption from metal surfaces by low-energy electrons. *J. Chem. Phys.* **41**:3311-28,1964.
3. **Madey T & Yates J. T**. Desorption methods as probes of kinetics and bonding at surfaces. *Surface Sci*, **63**:203-31,1977.
4. **Knotek M L & Feibelman P J.** Ion desorption by core-hole Auger decay. *Phys. Rev. Leu.* **40**:964-7,1978.