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What Happens When the Electron Beam Hits the Specimen

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When an electron passes through matter, the energy of the electron is transferred to the material in the form of ionizations and excitations. Almost all of this transfer is the result of the Coulomb interaction of the beam electrons with the electrons in the specimen; that is, scattering of beam electrons by nuclei is not an important energy-transfer process.

On average, about 30 eV is transferred for each ion pair (the electron and the parent atom*) produced, and most of the energy transferred goes into primary or secondary ionizations. In a typical energy-loss process, an electron can be removed from an inner shell (it can leave the atom with a velocity comparable to that of the incident electron). An electron from a higher shell then fills the hole left by the exiting electron producing an x-ray, and the removed electron and the x-ray interact further with the specimen, producing secondary ions. The figure of 30 eV per ion pair counts both the primary and secondary ions.

Thus, if a I MeV particle - proton, alpha or electron - is stopped in a material, roughly 30,000 ion pairs are produced. There are some variations which depend on the incident particle and the stopping material. One example is semiconductors, which produce about ten times more ion pairs per unit energy lost: this is one of the reason. that the energy resolution for semiconductor detectors is so good.

The products, obviously far from thermodynamic equilibrium, react with other components of the material causing chemical bond breaking and free radical formation. Finally (a few microseconds later) these reactive species form more stable products, which are often small organic molecules in the case of electrons incident on epoxy resin - the usual biological specimen. There is a statistical distribution of products which depends on the nature of the resin. In the case where the specimen is an alloy or a ceramic, the resulting products are simpler. Since many of these products are volatile, they will travel throughout the specimen chamber.

The remaining specimen is altered by this process. Defects are produced in materials by atoms displaced or removed and by rearrangement of chemical bonds, and organic materials usually experience greater mass loss than inorganic materials. Often pits can be observed in plastic sections, and some of the removed material can pile up near the damaged site, causing a cone of contamination if the incident beam has a small cross section.

Much of this information comes from Friedlander, G., J.W. Kennedy, E.S. Macias, and J.M. Miller, 1981, *Nuclear and Radiochemistry*, 3rd Edition. John Wiley & Sons, New York, Chichester, Brisbane, Toronto. ISBN 0-471-28021-6, ISBN 0-471-86255-X paperback . (I cannot recommend this book).

*By "parent atom" is meant all the atoms ionized by a particular cascade of events stemming from the initial interaction, and with the proviso that delocalized ions with one unit of positive charge can also be called parent atoms. For example, copper perchlorophthalocyanine is very radiation resistant since, upon losing an electron, the resonance structure and the d-orbitals of the Cu and Cl's can spread out the net charge, so no chemical bonds are broken before another electron gets to the molecule and neutralizes it. ■

A Correction!

In the Microscopy 101 Section of our May 1997 issue, we published the article "Suggestions to Improve the Lifetime of EDX Detector Windows" by Clark Turner, Moxtek, Inc. In this regard:

✓ The statement "Never pump down your specimen chamber with a x-ray detector attached" should have read "Never pump down your specimen chember with a WARM x-ray detector attached".

✓ The suggestion to "cover the detector with a plastic bag when it is not is use" is NOT a recommendation from either Dr. Turner or Moxtek, Inc.

We apologize to Dr. Turner, Moxtek and our readers for these errors . . Ed.

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✓ Aug 4/8 '97: **Denver X-Ray Conference.** Steam Springs, CO. Carole Collier, email: denxrcon@de.edu

✓ Aug 9/10 '97: **Multi-Photon Excitation Symposium and Workshop** (Univ of WI/Carnnegie Mellon Univ/MSA). Cleveland, OH. Dawn Volkman: (608)265-3083, dvolkman@students.wisc.edu

✓ Aug 10/15 '97: **Microscopy Society of America 55th Annual Meeting - Jointly with the Microbeam Analysis Society.** Cleveland, OH. MSA Business Office: (800)538-3672. Fax: (508)548-9053

✓ Aug 25/29 '97: **Computers in High-Resolution TEM** (NCEM Summer School), Berkeley, CA. Gretchen Hermes: http:ncem.lbl.gov, (510)486-5006, Fax: (510)486-5888, eMail: GHermes@lbl.gov

✓ Sept 7/11 '97: **111th AOAC International Annual Meeting & Eposition.** San Diego, CA. (800)379-2622, Fax: (301)924-7089

✓ Sept 7/12 '97: **11th CONF ON SIMS.** Santa |Fe NM: (505)989-4735, Fax: (505)989-1073.

✓ Sept 22/25 '97: **International Conference on Texture and Anisotropy of Polycrystals** (TU Clausthal, Germany). Robert Schwarzer: Fax: (+49)5323-722340, eMail: schwarzer@tu-clausthal.de

✓ Sept 25 '97: **Computers in Microscopy** (RMS) Cambridge, UK. Rebecca Morden: eMail: info@rms.org.uk

✓ Oct 5/8 '97: **Multinational Congress on Electron Microscopy.** Portoroz, Slovenia. http://www2.ijs.si/~k5www/MCEM97/index.html

✓ Oct 6/10 '97: **Scanning Electron Microscopy & X-ray Microanalysis.** (SUNY), New Palz, NY. Dr. A.V. Patsis: (914)244-0757, Fax: (914)255-0978

✓ Oct 8/16 '97: **Optical Microscopy and Imaging in the Biomedical Sciences** (Marine Biological Lab) Woods Hole, MA. Carol Hamel: (508)289-7401.

✓ Oct 20/24 '97: **44th AVS National Symposium.** San Jose, CA. Ms. Marion Churchill: AVS, 120 Wall St., 32nd Floor, New York NY 10005

✓ Nov. 16/20 '97: **Eastern Analytical Symposium.** Somerset, NJ. (302)738-6218, Fax: (302)738-5275.

✓ Dec 1/5 '97: **MRS Fall Meeting** Boston, MA. MRS: (412)367-3004, Fax: (412)367-4373

✓ May 9/12 '98: **SCANNING '98: (FAMS)** Baltimore, MD. Mary K. Sullivan:(201)818-0086, Fax: (201)818-0086, fams@holonet.net.Internet

✓ Aug 31 - Sept 4 '98: **ICEM XIV/International Congress on Electron Microscopy.** Cancun, Mexico. (525)553-4507, Fax: (525)553-4500, email: icem@icem.inin.mx

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