NOTES ON RADIATION EFFECTS ON MATERIALS pdf

1: Radiation effects on materials. | Physics Forums

Candyman, I can point you to some good references on the effects of radiation of materials. I have a list of texts, and if fact I will be reviewing a new book on the effects of radiation on materials which hopefully will be published by ANS next year.

This accumulation is limited by defect recombination, by clustering of defects, and by the annihilation of defects at sinks. Defects must thermally migrate to sinks, and in doing so often recombine, or arrive at sinks to recombine. One consequence of a flux of vacancies towards sinks is a corresponding flux of atoms away from the sink. If vacancies are not annihilated or recombined before collecting at sinks, they will form voids. At sufficiently high temperature, dependent on the material, these voids can fill with gases from the decomposition of the alloy, leading to swelling in the material. In many cases, the radiation flux is non-stoichiometric, which causes segregation within the alloy. This non-stoichiometric flux can result in significant change in local composition near grain boundaries, [10] where the movement of atoms and dislocations is impeded. When this flux continues, solute enrichment at sinks can result in the precipitation of new phases. Thermo-Mechanical effects of irradiation[edit] Hardening[edit] Radiation hardening is the strengthening of the material in question by the introduction of defect clusters, impurity-defect cluster complexes, dislocation loops, dislocation lines, voids, bubbles and precipitates. For pressure vessels, the loss in ductility that occurs as a result of the increase in hardness is a particular concern. Embrittlement[edit] Radiation embrittlement results in a reduction of the energy to fraction, due to a reduction in strain hardening as hardening is already occurring during irradiation. This is motivated for very similar reasons to those that cause radiation hardening; development of defect clusters, dislocations, voids, and precipitates. Variations in these parameters make the exact amount of embrittlement difficult to predict, [11] but the generalized values for the measurement show predictable consistency. Stress induces the nucleation of loops, and causes preferential absorption of interstitials at dislocations, which results in swelling. This phenomenon frequently occurs in zirconium, graphite, and magnesium because of natural properties. Conductivity[edit] Thermal and electrical conductivity rely on the transport of energy through the electrons and the lattice of a material. Defects in the lattice and substitution of atoms via transmutation disturb these pathways, leading to a reduction in both types of conduction by radiation damage. The magnitude of reduction depends on the dominant type of conductivity electronic or Wiedemannâ€"Franz law , phononic in the material and the details of the radiation damage and is therefore still hard to predict. Effects on gases[edit] Exposure to radiation causes chemical changes in gases. The least susceptible to damage are noble gases , where the major concern is the nuclear transmutation with follow-up chemical reactions of the nuclear reaction products. High-intensity ionizing radiation in air can produce a visible ionized air glow of telltale bluish-purplish color. The glow can be observed e. Significant amounts of ozone can be produced. Even small amounts of ozone can cause ozone cracking in many polymers over time, in addition to the damage by the radiation itself. The electrical discharges initiated by the ionization events by the particles result in plasma populated by large amount of free radicals. The highly reactive free radicals can recombine back to original molecules, or initiate a chain of free-radical polymerization reactions with other molecules, yielding compounds with increasing molecular weight. These high molecular weight compounds then precipitate from gaseous phase, forming conductive or non-conductive deposits on the electrodes and insulating surfaces of the detector and distorting its response. Gases containing hydrocarbon quenchers, e. Trace amounts of silicone oils , present from outgassing of silicone elastomers and especially from traces of silicone lubricants , tend to decompose and form deposits of silicon crystals on the surfaces. The oxygen is added as noble gas with carbon dioxide has too high transparency for high-energy photons ; ozone formed from the oxygen is a strong absorber of ultraviolet photons. Carbon tetrafluoride can be used as a component of the gas for high-rate detectors; the fluorine radicals produced during the operation however limit the choice of materials for the chambers and electrodes e. Addition of carbon tetrafluoride can however eliminate the silicon deposits. Presence of hydrocarbons with carbon tetrafluoride leads to polymerization. A mixture of argon, carbon tetrafluoride, and carbon dioxide shows low aging in high hadron flux. As with gases, one of the primary mechanisms is formation of free radicals. All liquids are subject to radiation damage, with few exotic exceptions; e. Effects on water[edit] Water subjected to ionizing radiation forms free radicals of hydrogen and hydroxyl , which can recombine to form gaseous hydrogen , oxygen , hydrogen peroxide , hydroxyl radicals , and peroxide radicals. In living organisms, which are composed mostly of water, majority of the damage is caused by the reactive oxygen species , free radicals produced from water. The free radicals attack the biomolecules forming structures within the cells , causing oxidative stress a cumulative damage which may be significant enough to cause the cell death, or may cause DNA damage possibly leading to cancer. In cooling systems of nuclear reactors, the formation of free oxygen would promote corrosion and is counteracted by addition of hydrogen to the cooling water. The reducing environment in pressurized water reactors is less prone to buildup of oxidative species. The chemistry of boiling water reactor coolant is more complex, as the environment can be oxidizing. Most of the radiolytic activity occurs in the core of the reactor where the neutron flux is highest; the bulk of energy is deposited in water from fast neutrons and gamma radiation, the contribution of thermal neutrons is much lower. In air-free water, the concentration of hydrogen, oxygen, and hydrogen peroxide reaches steady state at about Gy of radiation. In presence of dissolved oxygen, the reactions continue until the oxygen is consumed and the equilibrium is shifted. Neutron activation of water leads to buildup of low concentrations of nitrogen species; due to the oxidizing effects of the reactive oxygen species, these tend to be present in the form of nitrate anions. In reducing environments, ammonia may be formed. Ammonia ions may be however also subsequently oxidized to nitrates. Other species present in the coolant water are the oxidized corrosion products e. Behavior of supercritical water , important for the supercritical water reactors , differs from the radiochemical behavior of liquid water and steam and is currently under investigation. A gas-free water subjected to low-LET gamma rays yields almost no radiolysis products and sustains an equilibrium with their low concentration. High-LET alpha radiation produces larger amounts of radiolysis products. In presence of dissolved oxygen, radiolysis always occurs. Dissolved hydrogen completely suppresses radiolysis by low-LET radiation while radiolysis still occurs with The presence of reactive oxygen species has strongly disruptive effect on dissolved organic chemicals. This is exploited in groundwater remediation by electron beam treatment. In addition to the electronic device hardening mentioned above, some degree of protection may be obtained by shielding, usually with the interposition of high density materials particularly lead, where space is critical, or concrete where space is available between the radiation source and areas to be protected. For biological effects of substances such as radioactive iodine the ingestion of non-radioactive isotopes may substantially reduce the biological uptake of the radioactive form, and chelation therapy may be applied to accelerate the removal of radioactive materials formed from heavy metals from the body by natural processes. For solid radiation damage[edit] Solid countermeasures to radiation damage consist of three approaches. Firstly, saturating the matrix with oversized solutes. This acts to trap the swelling that occurs as a result of the creep and dislocation motion. They also act to help prevent diffusion, which restricts the ability of the material to undergo radiation induced segregation. Dispersed oxide helps to prevent creep, and to mitigate swelling and reduce radiation induced segregation as well, by preventing dislocation motion and the formation and motion of interstitials.

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2: Radiation damage - Wikipedia

Note: Citations are based on reference standards. However, formatting rules can vary widely between applications and fields of interest or study. The specific requirements or preferences of your reviewing publisher, classroom teacher, institution or organization should be applied.

March 15, Nevada Division of Environmental Protection The amount of radioactive material being released from the damaged nuclear reactors in Japan, and the eventual impact it will have on human health, are still being determined. How does nuclear radiation harm the body, and what are the risks from long-term exposure to low levels after an accident? MyHealthNewsDaily spoke with experts about these questions. How does radiation harm the body? As radioactive material decays, or breaks down, the energy released into the environment has two ways of harming a body that is exposed to it, Higley said. It can directly kill cells, or it can cause mutations to DNA. If those mutations are not repaired, the cell may turn cancerous. Radioactive iodine tends to be absorbed by the thyroid gland and can cause thyroid cancer , said Dr. Lydia Zablotska, an assistant professor in the department of epidemiology and biostatistics at the University of California, San Francisco. Children are most at risk for thyroid cancer, since their thyroid glands are 10 times smaller than those of adults, he said. The radioactive iodine would be more concentrated in them. Radioactive cesium, on the other hand, can stay in the environment for more than a century. But it does not concentrate in one part of the body the way radioactive iodine does. The Chernobyl accident released a plume of radioactive materials into the atmosphere in a fraction of a second. In the following years, the incidence of thyroid cancer among those exposed as children increased in Ukraine and nearby countries, Zablotska said. The cancer showed up between four and 10 years after the accident, Bouville said. Children were exposed to radioactive material mainly from eating contaminated leafy vegetables and dairy. There have been no detectable health effects from exposure to radioactive cesium after the accident. In general, it takes a pretty high dose of radiation to increase cancer risk, Higley said. For instance, there were reports that one Japanese worker was exposed to 10 rem millisievert, mSV , a measurement of radiation dose. From that exposure, his lifetime cancer risk would go up about half a percent, Higley said. According to Higley, the dose is the equivalent of about five CT scans. Americans are exposed to about 0. Potentially, exposure to any type of radiation can increase cancer risk, with higher exposure increasing the risk, Bouville said. No increases in cancer rates were observed after the release of radioactive from a power plant on Three Mile Island, Pa. Those exposed to high levels of radiation, about rem, millisievert could develop radiation sickness, Bouville said. A chest X-ray is about 0. People are exposed to about 0. Radiation sickness is often fatal and can produce such symptoms as bleeding and shedding of the lining on the gastrointestinal tract, Zablotska said. About people suffered from it as a result of the Chernobyl accident, Zablotska said. A radiation dose of 40 rem, mSv per hour was reported at one of the Japanese power plants at one point following the March 11 earthquakes and tsunami that damaged their cooling systems, according to the IAEA. This is a high dose but was isolated to a single location, the IAEA says. But the radiation levels have been decreasing after the observed spike, she said. She speculates the spike may have been due to the release of a puff of radioactive material when pressure dropped at the facility.

3: Radiation effects on electronic equipment

The effects of radiation from nuclear reactions on various classes of materials are examined in an introductory textbook for students of nuclear engineering. Topics discussed include the units and.

Ionizing radiation Some kinds of ionising radiation can be detected in a cloud chambers. Radiation with sufficiently high energy can ionize atoms; that is to say it can knock electrons off atoms, creating ions. Ionization occurs when an electron is stripped or "knocked out" from an electron shell of the atom, which leaves the atom with a net positive charge. Because living cells and, more importantly, the DNA in those cells can be damaged by this ionization, exposure to ionizing radiation is considered to increase the risk of cancer. Thus "ionizing radiation" is somewhat artificially separated from particle radiation and electromagnetic radiation, simply due to its great potential for biological damage. While an individual cell is made of trillions of atoms, only a small fraction of those will be ionized at low to moderate radiation powers. The probability of ionizing radiation causing cancer is dependent upon the absorbed dose of the radiation, and is a function of the damaging tendency of the type of radiation equivalent dose and the sensitivity of the irradiated organism or tissue effective dose. If the source of the ionizing radiation is a radioactive material or a nuclear process such as fission or fusion , there is particle radiation to consider. Particle radiation is subatomic particles accelerated to relativistic speeds by nuclear reactions. The exception is neutron particles; see below. There are several different kinds of these particles, but the majority are alpha particles , beta particles , neutrons , and protons. Roughly speaking, photons and particles with energies above about 10 electron volts eV are ionizing some authorities use 33 eV, the ionization energy for water. Particle radiation from radioactive material or cosmic rays almost invariably carries enough energy to be ionizing. Much ionizing radiation originates from radioactive materials and space cosmic rays , and as such is naturally present in the environment, since most rock and soil has small concentrations of radioactive materials. The radiation is invisible and not directly detectable by human senses; as a result, instruments such as Geiger counters are usually required to detect its presence. In some cases, it may lead to secondary emission of visible light upon its interaction with matter, as in the case of Cherenkov radiation and radio-luminescence. Graphic showing relationships between radioactivity and detected ionizing radiation Ionizing radiation has many practical uses in medicine, research and construction, but presents a health hazard if used improperly. Exposure to radiation causes damage to living tissue; high doses result in Acute radiation syndrome ARS , with skin burns, hair loss, internal organ failure and death, while any dose may result in an increased chance of cancer and genetic damage ; a particular form of cancer, thyroid cancer , often occurs when nuclear weapons and reactors are the radiation source because of the biological proclivities of the radioactive iodine fission product, iodine The International Commission on Radiological Protection states that "The Commission is aware of uncertainties and lack of precision of the models and parameter values", "Collective effective dose is not intended as a tool for epidemiological risk assessment, and it is inappropriate to use it in risk projections" and "in particular, the calculation of the number of cancer deaths based on collective effective doses from trivial individual doses should be avoided. Although present in space, this part of the UV spectrum is not of biological importance, because it does not reach living organisms on Earth. Some of the ultraviolet spectrum that does reach the ground the part that begins above energies of 3. This property gives the ultraviolet spectrum some of the dangers of ionizing radiation in biological systems without actual ionization occurring. In contrast, visible light and longer-wavelength electromagnetic radiation, such as infrared, microwaves, and radio waves, consists of photons with too little energy to cause damaging molecular excitation, and thus this radiation is far less hazardous per unit of energy. When an X-ray photon collides with an atom, the atom may absorb the energy of the photon and boost an electron to a higher orbital level or if the photon is very energetic, it may knock an electron from the atom altogether, causing the atom to ionize. Generally, larger atoms are more likely to absorb an X-ray photon since they have greater energy differences between orbital electrons. Soft tissue in the human body is composed of smaller atoms than the calcium atoms that make up bone, hence there is a contrast in the absorption of X-rays. X-ray machines are specifically designed to take advantage of the absorption difference between bone and soft tissue, allowing physicians to examine structure in the human body. Gamma radiation Gamma radiation detected in an isopropanol cloud chamber. Both alpha and beta particles have an electric charge and mass, and thus are quite likely to interact with other atoms in their path. Gamma radiation, however, is composed of photons, which have neither mass nor electric charge and, as a result, penetrates much further through matter than either alpha or beta radiation. Gamma rays can be stopped by a sufficiently thick or dense layer of material, where the stopping power of the material per given area depends mostly but not entirely on the total mass along the path of the radiation, regardless of whether the material is of high or low density. The atmosphere absorbs all gamma rays approaching Earth from space. Alpha radiation Alpha particle detected in an isopropanol cloud chamber Alpha particles are helium-4 nuclei two protons and two neutrons. They interact with matter strongly due to their charges and combined mass, and at their usual velocities only penetrate a few centimeters of air, or a few millimeters of low density material such as the thin mica material which is specially placed in some Geiger counter tubes to allow alpha particles in. This means that alpha particles from ordinary alpha decay do not penetrate the outer layers of dead skin cells and cause no damage to the live tissues below. Alpha radiation is dangerous when alpha-emitting radioisotopes are ingested or inhaled breathed or swallowed. This brings the radioisotope close enough to sensitive live tissue for the alpha radiation to damage cells. Per unit of energy, alpha particles are at least 20 times more effective at cell-damage as gamma rays and X-rays. See relative biological effectiveness for a discussion of this. Examples of highly poisonous alpha-emitters are all isotopes of radium , radon , and polonium , due to the amount of decay that occur in these short half-life materials. It is more penetrating than alpha radiation, but less than gamma. Beta radiation from radioactive decay can be stopped with a few centimeters of plastic or a few millimeters of metal. It occurs when a neutron decays into a proton in a nucleus, releasing the beta particle and an antineutrino. Beta radiation from linac accelerators is far more energetic and penetrating than natural beta radiation. It is sometimes used therapeutically in radiotherapy to treat superficial tumors. When a positron slows to speeds similar to those of electrons in the material, the positron will annihilate an electron, releasing two gamma photons of keV in the process. Those two gamma photons will be traveling in approximately opposite direction. The gamma radiation from positron annihilation consists of high energy photons, and is also ionizing. Neutron radiation Main articles: Neutron radiation consists of free neutrons. These neutrons may be emitted during either spontaneous or induced nuclear fission. Neutrons are rare radiation particles; they are produced in large numbers only where chain reaction fission or fusion reactions are active; this happens for about 10 microseconds in a thermonuclear explosion, or continuously inside an operating nuclear reactor; production of the neutrons stops almost immediately in the reactor when it goes non-critical. Neutrons are the only type of ionizing radiation that can make other objects, or material, radioactive. This process, called neutron activation , is the primary method used to produce radioactive sources for use in medical, academic, and industrial applications. Even comparatively low speed thermal neutrons cause neutron activation in fact, they cause it more efficiently. Neutrons do not ionize atoms in the same way that charged particles such as protons and electrons do by the excitation of an electron , because neutrons have no charge. It is through their absorption by nuclei which then become unstable that they cause ionization. Hence, neutrons are said to be "indirectly ionizing. Not all materials are capable of neutron activation; in water, for example, the most common isotopes of both types atoms present hydrogen and oxygen capture neutrons and become heavier but remain stable forms of those atoms. Only the absorption of more than one neutron, a statistically rare occurrence, can activate a hydrogen atom, while oxygen requires two additional absorptions. Thus water is only very weakly capable of activation. The sodium in salt as in sea water , on the other hand, need only absorb a single neutron to become Na, a very intense source of beta decay, with half-life of 15 hours. In addition, high-energy high-speed neutrons have the ability to directly ionize atoms. One mechanism by which high energy neutrons ionize atoms is to strike the nucleus of an atom and knock the atom out of a molecule, leaving one or more electrons behind as the chemical bond is broken. This leads to production of chemical free radicals. In addition, very high energy neutrons can cause ionizing radiation by "neutron spallation" or knockout, wherein neutrons cause emission of high-energy protons from atomic nuclei especially hydrogen nuclei on impact. The charged protons and other products from such reactions are directly ionizing. High-energy neutrons are very penetrating and can travel great distances in air hundreds or even thousands of meters and moderate distances several meters in common solids. They typically require hydrogen rich shielding, such as concrete or water, to block them within distances of less than a meter. A common source of neutron radiation occurs inside a nuclear reactor , where a meters-thick water layer is used as effective shielding. Cosmic radiation Main article: The sun continuously emits particles, primarily free protons, in the solar wind, and occasionally augments the flow hugely with coronal mass ejections CME. The particles from deep space inter- and extra-galactic are much less frequent, but of much higher energies. These particles are also mostly protons, with much of the remainder consisting of helions alpha particles. A few completely ionized nuclei of heavier elements are present. The origin of these galactic cosmic rays is not yet well understood, but they seem to be remnants of supernovae and especially gamma-ray bursts GRB , which feature magnetic fields capable of the huge accelerations measured from these particles. Non-ionizing radiation The electromagnetic spectrum The kinetic energy of particles of non-ionizing radiation is too small to produce charged ions when passing through matter. For non-ionizing electromagnetic radiation see types below , the associated particles photons have only sufficient energy to change the rotational, vibrational or electronic valence configurations of molecules and atoms. The effect of non-ionizing forms of radiation on living tissue has only recently been studied. Nevertheless, different biological effects are observed for different types of non-ionizing radiation. These reactions occur at far higher energies than with ionization radiation, which requires only single particles to cause ionization. A familiar example of thermal ionization is the flame-ionization of a common fire, and the browning reactions in common food items induced by infrared radiation, during broiling-type cooking. The electromagnetic spectrum is the range of all possible electromagnetic radiation frequencies. The non-ionizing portion of electromagnetic radiation consists of electromagnetic waves that as individual quanta or particles, see photon are not energetic enough to detach electrons from atoms or molecules and hence cause their ionization. These include radio waves, microwaves, infrared, and sometimes visible light. The lower frequencies of ultraviolet light may cause chemical changes and molecular damage similar to ionization, but is technically not ionizing. The highest frequencies of ultraviolet light, as well as all X-rays and gamma-rays are ionizing. The occurrence of ionization depends on the energy of the individual particles or waves, and not on their number. An intense flood of particles or waves will not cause ionization if these particles or waves do not carry enough energy to be ionizing, unless they raise the temperature of a body to a point high enough to ionize small fractions of atoms or molecules by the process of thermal-ionization this, however, requires relatively extreme radiation intensities. Ultraviolet light Main article: Ultraviolet As noted above, the lower part of the spectrum of ultraviolet, called soft UV, from 3 eV to about 10 eV, is non-ionizing. However, the effects of non-ionizing ultraviolet on chemistry and the damage to biological systems exposed to it including oxidation, mutation, and cancer are such that even this part of ultraviolet is often compared with ionizing radiation. Visible light Main article: Infrared Infrared IR light is electromagnetic radiation with a wavelength between 0. IR wavelengths are longer than that of visible light, but shorter than that of microwaves. Infrared may be detected at a distance from the radiating objects by "feel. Bright sunlight provides an irradiance of just over 1 kilowatt per square meter at sea level. Microwave In electromagnetic radiation such as microwaves from an antenna, shown here the term "radiation" applies only to the parts of the electromagnetic field that radiate into infinite space and decrease in intensity by an inverse-square law of power so that the total radiation energy that crosses through an imaginary spherical surface is the same, no matter how far away from the antenna the spherical surface is drawn. Electromagnetic radiation includes the far field part of the electromagnetic field around a transmitter.

4: How Does Nuclear Radiation Harm the Body?

Qualitative Radiation Effects in Structural Materials - Nuclear Materials Slide 1. Figures taken from G. S. Was, "Fundamentals of Radiation Materials Science" unless otherwise noted.

The following question was answered by an expert in the appropriate field: Q My question is in regard to the effect of radioactivity on nonliving matter and, specifically, electrical systems. What happens to things like record players, radios, intercom systems, TVs, and the like when exposed to beta and gamma rays? I have read conflicting information, including a claim that the effects would worsen and lessen as the radiation source drew nearer and farther away. Does the radiation exposure break down the physical material or does it mess with the signals received by the devices? Would the effects go away if the devices were removed from the presence of the radiation source? A Radiation effects on electrical equipment depend on the equipment and on the type of ionizing radiation to which it is exposed. Gamma radiation is penetrating and can affect most electrical equipment. Diodes and computer chips electronics are much more sensitive to gamma radiation. To give you a comparison of effects, it takes a radiation dose of about 5 Sv to cause death to most people. Diodes and computer chips will show very little functional detriment up to about 50 to Sv. Also, some electronics can be "hardened" made to be not affected as much by larger gamma radiation doses by providing shielding or by selecting radiation-resistant materials. Some electronics do exhibit a recovery after being exposed to gamma radiation, after the radiation is stopped. Also, if the electronics are exposed to gamma radiation while unpowered, the gamma radiation effects are less. Ionizing radiation breaks down the materials within the electrical equipment. For example, when wiring is exposed to gamma rays, no change is noticed until the wiring is flexed or bent. The effect on diodes and computer chips is a bit more complex. The gamma rays disrupt the crystalline nature of the inside of the electronic component. Its function is degraded and then fails as more gamma radiation exposure is received by the electronic component. Gamma rays do not affect the signals within the device or the signals received by the device. I put a cheap electronic game in my microwave oven at home. It arced and sparked and was totally ruined. The information posted on this web page is intended as general reference information only. Specific facts and circumstances may affect the applicability of concepts, materials, and information described herein. The information provided is not a substitute for professional advice and should not be relied upon in the absence of such professional advice. To the best of our knowledge, answers are correct at the time they are posted. Be advised that over time, requirements could change, new data could be made available, and Internet links could change, affecting the correctness of the answers. Answers are the professional opinions of the expert responding to each question; they do not necessarily represent the position of the Health Physics Society.

5: Radiation Protection | US EPA

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6: Radiation | Nuclear Radiation | Ionizing Radiation | Health Effects - World Nuclear Association

Notes on Radiation Effects on Materials 1st Edition by James N. Anno (Author) Be the first to review this item.

7: Radiation - Wikipedia

The study of radiation effects has developed as a major field of materials science from the beginning, approximately 70 years ago. Its rapid development has been driven by two strong influences. The properties of the crystal defects and the materials containing them may then be studied.

NOTES ON RADIATION EFFECTS ON MATERIALS pdf

8: James N. Anno (Author of Notes on Radiation Effects on Materials)

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