GAS DISCHARGE PHYSICS pdf

1: Gas Discharge Physics - Yuri P Raizer, John E Allen - HÃ¤ftad () | Bokus

Gas Discharge Physics Here is both a textbook for beginners and a handbook for specialists in plasma physics and gaseous electronics. The book contains much useful data: results of experiments and calculations, and reference data.

Introduction An electrical discharge results from the creation of a conducting path between two points of different electrical potential in the medium in which the points are immersed. If the supply of electrical charge is continuous, the discharge is permanent, but otherwise it is temporary, and serves to equalize the potentials. Usually, the medium is a gas, often the atmosphere, and the potential difference is a large one, from a few hundred volts to millions of volts. If the two points are separated by a vacuum, there can be no discharge. The transfer of matter between the two points is necessary, since only matter can carry electric charge. This matter is usually electrons, each carrying a charge of 4. Electrons are very light, 9. However, ions can also carry charge, although they are more than times heavier, and sometimes are important carriers. Where both electrons and ions are available, however, the electrons carry the majority of the current. Ions can be positively or negatively charged, usually positively, and carry small multiples of the electronic charge. Electrical discharges have been studied since the middle of the 19th century, when vacuum pumps and sources of current electricity became available. These laboratory discharges in partially-evacuated tubes are very familiar, but there are also electrical discharges in nature, lightning being the primary example. There are also the aurora borealis and australis, St. Technology offers a wealth of examples, such as arc welding, the corona discharge on high-tension lines, fluorescent lamps, including their automatic starters, neon advertising signs, neon and argon glow lamps, mercury and sodium lamps, mercury-arc lamps for illumination and UV, carbon arc lights, vacuum tubes, including gas-filled rectifiers, Nixie numerical indicators and similar devices. Some of these are historical, but all are interesting and often fascinating to watch. A good reason for this article is also that information on electrical discharges is not easy to find in current literature, in spite of their importance in many fields of physics, astrophysics, atmospheric electricity and engineering. The McGraw-Hill Encyclopedia of Physics has no entry for "electrical discharge" or "electric arc," for example. The closest one can come are articles on plasma physics, which do not do the job. Plasma physics, as it is generally presented, is a rather limited field mainly concerned with the luckless search for thermonuclear power. Every day we see many examples of discharges--street lights, neon signs, fluorescent lamps--so how they work must be valuable knowledge. The two termini of a discharge are at different potentials. The higher, or positive, potential is at the anode, while the lower, or negative, potential is at the cathode. These electrodes are often conductors, but need not be. In a thunderstorm, a cloud electrode may simply be a region of excess charge distributed over a volume. The conventional current is in the direction of positive charge, so electrons actually leave at the "way in" and enter at the "way out. In technical work, gas pressure is measured in mmHg, and mmHg is atmospheric pressure, 1. At one atmosphere and K, the number density in a gas is 3. The gas is normally electrically neutral, and contains neither ions nor electrons, and so is a nonconductor. In daily life, we rely on the air to be an insulator in our dealings with electricity. The electrons, ions and neutral molecules are in incessant thermal motion, because their collisions are perfectly elastic. The electron temperature Te is usually very different from the ion and neutral temperature Tn at low pressures, because the electrons receive more energy from the electric fields in a discharge, and can exchange kinetic energy with the neutrals only with great difficulty, so they represent a reservoir of kinetic energy that is in very weak contact with the neutrals. The much greater mass of the ions and neutrals also means that they move at much lower velocities. Speeds given to the electrons by electric fields are often very much greater than thermal speeds, especially near the cathode, where the electric field is very high. These electrons, naturally, do not have a Maxwellian distribution until they have lost most of their energy in inelastic collisions and ionization. Again, in technical work, V is measured in practical volts, the familiar ones in which a flashlight battery supplies 1. The Gaussian unit is the esu, about V, which appears in theoretical arguments. This average field will drive a positive ion in its direction, an electron in the opposite direction. For a discharge to occur, there must usually be a source of electrons at the cathode, and the nature of this source controls the form of the discharge. Cosmic rays and natural radioactivity continually produce a small number of electrons and ions in all gases at the surface of the earth, and this gives air a small conductivity. The electrons will migrate to the anode, the ions to the cathode, and a small current will flow. This current has no visible effects, and can be detected and measured only with difficulty, but is always present. Any charged body attracts charges of the opposite sign that sooner or later will neutralize its charge, though the usual reason for the loss of charge is conduction over the surface of the supports of the body, which is normally far greater than the small space current from the ions and electrons normally present in the air. More copious sources of electrons are necessary for a good discharge. One source is the photoelectric effect, when light of sufficiently short wavelength falls on a metal or semiconductor and liberates a photoelectron. Photons can also be absorbed by a molecule, which gives up an electron and becomes a positive ion. Thermionic emission, the emission of electrons by a heated body, can supply heavy currents. The body must be heated to incandescence, and for efficient emission, its work function must be low. Tungsten has a work function of 4 eV, and has long been used as an electron emitter, since it also has a high melting point. Alkali metals have a small work function, but cannot be used by themselves because of their low melting points. Electrons striking a metal surface can knock loose secondary electrons readily, but this is of little use for discharges, since the electrons impact the anode, and secondary electrons would simply fall back into the anode, not add to the discharge current. However, positive ions can also create secondary electrons. Although this is not an efficient process, it produces electrons at the right place and can support a discharge. Electrons already in the discharge, such as the random electrons produced by cosmic rays and radioactivity, can add to their number by ionizing gas molecules by collision. Each ionizing collision produces a new electron, and a positive ion that moves the other way, an ion pair. An electron cannot do this unless it has acquired sufficient kinetic energy by being accelerated in an electric field. There are two ways this can be done. If the electron makes no collisions, even a small electric field will allow it to accumulate energy in a long-enough run. Then, the only way for the electron to accelerate is to find a larger field E. The mean free path L is inversely proportional to the pressure, so pressure has a great effect on how an electron gains energy. The molecules of the gas also have a mean free path, but since molecules are larger, their mean free path L is shorter than Le. In Ne, the mean free path at mmHg and K is 1. By "air" we mean the usual mixture of nitrogen and oxygen, and the values are an average. To raise a Ne atom to its first excited state requires This gives an idea of the energy required to produce an ion pair. Since most collisions do not result in ionization, and there are many ways to fritter energy away uselessly, the average energy per ion pair produced is greater than the ionization potential, rather closer to twice this value. The energy required to excite a molecule or atom to its first excited state above the ground state is called the resonance energy, and is, of course, less than the ionization energy. The inert gases, which have a closed shell of electrons in the ground state, have very large resonance energies. For He, it is These levels are also metastable, which means that a transition to the ground state by radiation is difficult, and they may retain their excitation energy for an extended period, perhaps until they collide with a wall, or experience another collision with an electron or atom. This makes cumulative ionization possible, where an atom can be ionized by multiple collisions in which the electrons have insufficient energy to ionize in a single collision. The energy of a metastable can be transferred to a different atom or molecule by a collision of the second kind. Alkali metals, with a single s electron outside a closed shell, have very low resonance potentials. For caesium, the figures are 3. The spectroscopic notation is included for those who will appreciate it. The fundamentals of atomic structure and spectra are important in understanding discharges. The emission of light is one of the principal characteristics of discharges. Light of a definite frequency is emitted when an excited atom falls to a lower energy level. If there is an electric dipole transition moment, then the transition is called allowed, and occurs in about s if nothing intervenes. The collision frequency is about per second at atmospheric pressure, so usually the excitation energy is lost in a collision before it can be radiated. At 1 mmHg, however, the collision frequency is comparable to the radiation lifetime, and radiation is a possibility. Radiation is always a competetion between de-excitation processes. If the dipole transition moment is forced to be zero by symmetry considerations, then radiation may occur by other means, such as magnetic dipole or quadrupole radiation, but the radiative lifetime for these is much longer, so they are not seen even at 1 mmHg pressure. These are forbidden transitions. They are not really forbidden, just improbable. At higher pressures, excited atoms are continually affected by collisions, which broaden the lines emitted. At still higher pressures, the atom states are smeared out, and the radiation begins to assume the characteristics of black-body thermal radiation. Mercury has strong lines at The first is the resonance line in the ultraviolet that strongly excites fluorescence, and the next two are at the short-wavelength limit of human vision. The cyan line at nm, the green line at nm, and the yellow doublet at and nm can easily be seen in the spectrum of a fluorescent tube, and should be familiar to all. They can be separated by filters for use in optics experiments, and this was commonly done before the He-Ne laser appeared around The nm, nm and nm lines are all "forbidden" by the usual selection rules, but happen to be very strong in Hg, where singlet-triplet combinations among lower levels are not very forbidden. If an electron frees another by an ionizing collision, then these two can both free additional electrons, and so on. This creates an electron avalanche, which may send a burst of electrons toward the anode, leaving in their wake a cloud of slow positive ions that will make their way to the cathode. The net result is to multiply the original electron current, an effect used in gas phototubes to increase the photocurrent for a given amount of light. This does not start a sustained discharge, but merely increases the current that otherwise would be available. This type of discharge produces little light, so it is called a dark or Townsend discharge, after the man who studied them in detail first. That cloud of positive ions will sooner or later collide with the cathode. It is rather unlikely for a positive ion to snatch an electron from the few that are available while it is moving through the gas. Recombination is a very difficult process, since only one particle is the outcome, rather than the three particles that come out of an ionization, so it is hard to conserve both momentum and energy.

2: Modeling of gas discharge plasma - IOPscience

Gas Discharge Physics has 3 ratings and 0 reviews. Here is both a textbook for beginners and a handbook for specialists in plasma physics and gaseous ele.

Eric Schiff, chair of the department of physics at Syracuse University, provides this explanation. Neon signs are orange, like the word physics above. By definition, the atoms of inert gases such as helium, neon or argon never well, almost never form stable molecules by chemically bonding with other atoms. But it is pretty easy to build a gas discharge tubesuch as a neon lightwhich reveals that inertness is a relative matter. One need apply only a modest electric voltage to electrodes at the ends of a glass tube containing the inert gas and the light begins to glow. The voltage across a discharge tube will accelerate a free electron up to some maximum kinetic energy. The voltage must be large enough so that this energy is more than that required to "ionize" the atom. An ionized atom has had an electron plucked out of an orbital to make it a "free" particle, and the atom it leaves behind has become a positively charged ion. The photo above shows a gas discharge sign designed by Sam Sampere of Syracuse University. This sign incorporates a neon discharge tube the orange word "Physics" and mercury discharge tubes the blue word "Experience" and the outer frame. The sculpture at the bottom of the sign represents the electric and magnetic fields of light. The white and yellow sine waves in the sculpture are actually fluorescent lights. These fluorescent lights are mercury discharge tubes with special coatings on their inner walls. The ultraviolet light emitted by the mercury discharge inside a tube is absorbed by the coating, which subsequently emits light of a different color and with a lower photon energy. Depending on the exact material of the coating, a whole range of colors can be obtained. So why do these gas discharges emit light? As an alternative to being removed by an energetic collision, an electron on an atom can be excited. One speaks of the electron as having been promoted to an orbital of higher energy. When the electron eases back down to its original orbital, a particle of light a photon carries away the energy of excitationand the discharge tube glows! A given atom can emit photons at many energies corresponding to its different pairs of orbitals. This series of photon energiesthe emission lines to a spectroscopistis unique to a particular atom. As can be seen in the sign, the mercury discharge tubes have a very different hue than the neon discharge tube does. The inert gas helium was actually discovered this way, and observations of sunlight revealed a series of photon energies that had never before been seen in discharges on the earth. The chemical inertness of certain gases is subtler to explain. Generally speaking, when two atoms come into proximity, the highest energy, or valence, orbitals of the atoms change substantially and the electrons on the two atoms reorganize. If this reorganization lowers the total energy of the electrons involved, a chemical bond can form. For ordinary, non-inert atoms, the electrons are relatively pliable and bonds often form. The electrons in inert gases, however, are relatively resistant to this proximity effect, so these gases very rarely bond to form molecules. The apparent contradiction between the inertness of a gas with respect to chemical bonding and its liveliness in a glow discharge is an example of a broader phenomenon that we might call the unbearable inertness of matter. Atoms of inert gases like neon are the most tenaciously laid back. Still, as interaction energies increase, even they lose their inertness, and we ultimately get a soup of inert nuclei and electronsa highly excited plasma. Increase the energy more actually, a lot more , and the nuclei are no longer so inert either. We get instead a brew of nucleonsas in a neutron star. Step up the energy some more, and we enter the realm of quarks. Here even nucleons are no longer inertand we have returned to the incredibly energetic, primordial conditions that prevailed shortly after the big bang. Answer originally posted December 4,

3: Conferences and Meetings on Plasma and Gas-discharge Physics

Introduction.- What Is the Subject of Gas Discharge Physics.- Typical Discharges in a Constant Electric Field.- Classification of Discharges.- Brief History of Electric Discharge Research.- Organization of the Book.

Electrical components such as transformers , capacitors , electric motors and generators: Corona can progressively damage the insulation inside these devices, leading to equipment failure. Elastomer items such as O-rings can suffer ozone cracking Plastic film capacitors operating at mains voltage can suffer progressive loss of capacitance as corona discharges cause local vaporization of the metallization [6] In many cases coronas can be suppressed by corona rings , toroidal devices that serve to spread the electric field over larger area and decrease the field gradient below the corona threshold. Mechanism[edit] Corona discharge results when the electric field is strong enough to create a chain reaction: The diagrams below illustrate at a microscopic scale the process which creates a corona in the air next to a pointed electrode carrying a high negative voltage with respect to ground. A neutral atom or molecule, in a region of strong electric field such as the high potential gradient near the curved electrode is ionized by a natural environmental event for example, being struck by an ultraviolet photon or cosmic ray particle , to create a positive ion and a free electron. The electric field accelerates these oppositely charged particles in opposite directions, separating them, preventing their recombination, and imparting kinetic energy to each of them. It gains enough energy from the field that when it strikes another atom it ionizes it, knocking out another electron, and creating another positive ion. Both positive and negative coronas rely on electron avalanches. In a positive corona all the electrons are attracted inward toward the nearby positive electrode and the ions are repelled outwards. In a negative corona the ions are attracted inward and the electrons are repelled outwards. The glow of the corona is caused by electrons recombining with positive ions to form neutral atoms. When the electron falls back to its original energy level, it releases a photon of light. The photons serve to ionize other atoms, maintaining the creation of electron avalanches. At a certain distance from the electrode, the electric field becomes low enough that it no longer imparts enough energy to the electrons to ionize atoms when they collide. This is the outer edge of the corona. Outside this the ions move through the air without creating new ions. The outward moving ions are attracted to the opposite electrode and eventually reach it and combine with electrons from the electrode to become neutral atoms again, completing the circuit. Thermodynamically, a corona is a very nonequilibrium process, creating a non-thermal plasma. The avalanche mechanism does not release enough energy to heat the gas in the corona region generally and ionize it, as occurs in an electric arc or spark. Only a small number of gas molecules take part in the electron avalanches and are ionized, having energies close to the ionization energy of 1â€”3 ev, the rest of the surrounding gas is close to ambient temperature. Later papers derived more accurate formulas. Properties[edit] A positive corona is manifested as a uniform plasma across the length of a conductor. The uniformity of the plasma is caused by the homogeneous source of secondary avalanche electrons described in the mechanism section , below. With the same geometry and voltages, it appears a little smaller than the corresponding negative corona, owing to the lack of a non-ionising plasma region between the inner and outer regions. A positive corona has much lower density of free electrons compared to a negative corona; perhaps a thousandth of the electron density, and a hundredth of the total number of electrons. However, the electrons in a positive corona are concentrated close to the surface of the curved conductor, in a region of high potential gradient and therefore the electrons have a high energy , whereas in a negative corona many of the electrons are in the outer, lower-field areas. Therefore, if electrons are to be used in an application which requires a high activation energy, positive coronas may support a greater reaction constants than corresponding negative coronas; though the total number of electrons may be lower, the number of very high energy electrons may be higher. Coronas are efficient producers of ozone in air. A positive corona generates much less ozone than the corresponding negative corona, as the reactions which produce ozone are relatively low-energy. Therefore, the greater number of electrons of a negative corona leads to an increased production. Beyond the plasma, in the unipolar region, the flow is of low-energy positive ions toward the flat electrode. Mechanism[edit] As with a negative corona, a positive corona is initiated by an exogenous ionisation event in a region of high potential gradient. The electrons resulting from the ionisation are attracted toward the curved electrode, and the positive ions repelled from it. By undergoing inelastic collisions closer and closer to the curved electrode, further molecules are ionized in an electron avalanche. In a positive corona, secondary electrons, for further avalanches, are generated predominantly in the fluid itself, in the region outside the plasma or avalanche region. They are created by ionization caused by the photons emitted from that plasma in the various de-excitation processes occurring within the plasma after electron collisions, the thermal energy liberated in those collisions creating photons which are radiated into the gas. The electrons resulting from the ionisation of a neutral gas molecule are then electrically attracted back toward the curved electrode, attracted into the plasma, and so begins the process of creating further avalanches inside the plasma. Properties[edit] A negative corona is manifested in a non-uniform corona, varying according to the surface features and irregularities of the curved conductor. It often appears as tufts of corona at sharp edges, the number of tufts altering with the strength of the field. The form of negative coronas is a result of its source of secondary avalanche electrons see below. It appears a little larger than the corresponding positive corona, as electrons are allowed to drift out of the ionising region, and so the plasma continues some distance beyond it. The total number of electrons, and electron density is much greater than in the corresponding positive corona. However, they are of a predominantly lower energy, owing to being in a region of lower potential-gradient. Therefore, whilst for many reactions the increased electron density will increase the reaction rate, the lower energy of the electrons will mean that reactions which require a higher electron energy may take place at a lower rate. Mechanism[edit] Negative coronas are more complex than positive coronas in construction. As with positive coronas, the establishing of a corona begins with an exogenous ionization event generating a primary electron, followed by an electron avalanche. Electrons ionized from the neutral gas are not useful in sustaining the negative corona process by generating secondary electrons for further avalanches, as the general movement of electrons in a negative corona is outward from the curved electrode. For negative corona, instead, the dominant process generating secondary electrons is the photoelectric effect , from the surface of the electrode itself. The work function of the electrons the energy required to liberate the electrons from the surface is considerably lower than the ionization energy of air at standard temperatures and pressures, making it a more liberal source of secondary electrons under these conditions. Again, the source of energy for the electron-liberation is a high-energy photon from an atom within the plasma body relaxing after excitation from an earlier collision. The use of ionized neutral gas as a source of ionization is further diminished in a negative corona by the high-concentration of positive ions clustering around the curved electrode. Under other conditions, the collision of the positive species with the curved electrode can also cause electron liberation. The difference, then, between positive and negative coronas, in the matter of the generation of secondary electron avalanches, is that in a positive corona they are generated by the gas surrounding the plasma region, the new secondary electrons travelling inward, whereas in a negative corona they are generated by the curved electrode itself, the new secondary electrons travelling outward. A further feature of the structure of negative coronas is that as the electrons drift outwards, they encounter neutral molecules and, with electronegative molecules such as oxygen and water vapor , combine to produce negative ions. Corona discharge on a Wartenberg wheel Ionized gases produced in a corona discharge are accelerated by the electric field, producing a movement of gas or electrical wind. A pinwheel, with radial metal spokes and pointed tips bent to point along the circumference of a circle, can be made to rotate if energized by a corona discharge; the rotation is due to differential electric attraction between the metal spokes and the space charge shield region that surrounds the tips.

4: How do neon lights work? - Scientific American

1. Introduction.- What Is the Subject of Gas Discharge Physics.- Typical Discharges in a Constant Electric Field.- Classification of Discharges.- Brief History of Electric Discharge Research.- Organization of the Book.

5: Gas Discharge Lamps â€“ A Requiem | Department of Physics

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motion of ions in a gas will be discussed as this eventually leads to the formation of a gas discharge. Classiï¬•cation of Gas Discharges Gas discharges can be broadly classiï¬•ed into two groups 2 based on how they are operated.

7: Corona discharge - Wikipedia

If we reduce the gas pressure to between 1 mmHg and 1 cmHg, we get a glow discharge that looks like the one in the diagram, a typical low-pressure glow discharge. If we started with the pressure at atmospheric, we would find it impossible to start a discharge with, say E = V.

8: Electrical Discharges

one of the most mystifying phenomena in the physics of gas discharge plasmas. Langmuir first observed this phenomenon in the s, and returned repeatedly to this paradoxical discrepancy between experiment and an estimate that.

9: Introduction to gas discharges - IOPscience

Introduction to gas discharges gas discharge plasmas are described in terms of phenomena observed in the laboratory. discussions about the physics of.

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What makes young democracies different? Buying and Believing Women of Izmaelovka Clary cried out. / V. 1. Medical ethics and etiquette in the eighteenth century The Mudfog Papers (Pocket Classics) Dfd diagram hotel management system Fatherhood and lessons Water pumping windmill plans Victorian painting Courts in American popular culture Lynn Mather Etienne Dolet The Martyr Of The Renaissance 1508 To 1546 The House of Beartown Road Is college an option? Eaglesmere Lakes Trail At the heart of the city X. The poets gentleman. Both wrong, both loved String theory volume 2 A vacationers guide to Orlando central Florida Parachute soldiers post war odyssey The book of absent people City of god st augustine GAAP Financial Statement Disclosures Manual, 2006-2007 New English Bible, companion to the New Testament: the Gospels Make indesign interactive for Romulan Ship Recognition Manual (Star Trek RPG) Advanced Technology Concepts for Command and Control Nancy : a love story Foreign silver coins (p. 58-66) Probate and administration in Singapore and Malaysia Cabbage Patch Pong Some reflexes of the Indo-European laryngeals in the Slav prosodic paradigms World Football League Encyclopedia Ntse syllabus 2017 Guns at Muleshoe. The Young In One Anothers Arms (Little Sisters Classics) 1. Associations and Guilds: Varieties and Social Makeup A new fellowship: modern examples of Christian cooperation A Dylan Thomas Companion