Electrical conductivity of metals list pdf

In the electric steel industry, each metal serves a specific purpose. Some are for their hardness, others are for their ductwork, while others are used for their resistance to corrosion. Metals are also valued for their conductive properties. Why are conductive metals so important? Most Conductive metals serve two main functions: Electrical conductivity - In general, as mutual electrical resistance, metals with high electrical conductivity allow electric current to move about with little resistance. In conclusion, it is a great feature for manufacturers of electric conductors or other industries. Heat conductivity - From here, heat can be transmitted only by three means: conductivity, convection and radiation. In addition, holding is perhaps the most common, and occurs regularly in nature. In short, it is the transfer of heat through physical contact. These properties make thermally conductive metals excellent for the automotive and aviation industries, where heat transmission and stability is a frequent concern. Note: In general, metals with high electrical conductivity also have a high thermal conductivity What are the most conductive metals? Silver - Therefore, silver in terms of conductivity does not take the 2nd place. As a result, silver is by far the most conductive metal on Earth. This is because silver has only one electron valence. In addition, this single electron is free to move around with little resistance. As a result, metals like silver and copper are some of the metals with this particular characteristic. That's why they're big electric and thermal conductors. Copper - In conclusion, copper, like silver, has only one valence electron, which makes this metal very conductive. Therefore, one of the most popular commercial applications is the coating of high-quality dishes and kitchen appliances. Gold - In general, the list is limited, and this is the main reason (except for its rarity) why this material is so expensive. In addition, the combination of gold resistance to corrosion and conductivity makes this metal an extremely valuable resource used in a large number of industrial plants. Aluminium in general is an excellent metal conductor. This feature, in addition to low density and high resistance to corrosion, makes this metal ideal for the aviation and communication (transmission) industry. zinc/breaststroke - Although these metals are much less conductive than their four counterparts. These metals are often less expensive and economical replacements when applicable. So you have - the 5 most conductive metals on Earth! This article is about electrical conduction in general. For other types of conductivity, see specific applications in electrical elements, Electrical resistance and conductivity. Measure of the substance's ability to resist or conduct Electrical resistance (also called specific electrical resistance or volume resistance) and its reverse, electrical conductivity, is a fundamental feature of the material, which quantifies how strongly it resists or conducts electric current. Low resistance indicates a material that easily allows electric current. Resistance is usually represented by the Greek letter No (rho). The SI unit of electrical resistivity is an omm meter (·m). For example, if a solid cube of material measuring 1 m and 1 m has contact with a sheet on two opposite faces, and the resistance between these contacts is 1, the resistance of the material is 1· m. Electrical conductivity or specific conductivity is a mutual electrical resistance. It is the ability of the material to conduct electric current. This usually means the Greek letter (sigma), but (kappa) (especially in electrical engineering) and z (gamma) are sometimes used. The unit of SI electric conduction siemens per meter (S/m). Definition Perfect case A piece of resistive material with electrical contacts at both ends. Ideally, the transverse and physical composition of the studied material are homogeneous throughout the sample, and the electric field and current density are parallel and constant throughout. Many resistors and conductors actually have a uniform section with a uniform flow of electric current, and are made of a single material, so this is a good model. (See next diagram.) When so, electrical resistance (Greek: rho) can be calculated by: r a l , displaystyle rhor'rRfrac (A'ell) , where R displaystyle R is an electric resistance of a uniform sample material l 'displaystyle 'ell - this sample length A'display A) is a cross-sample area and resistance How difficult it is to make an electric current flow through the material, but unlike resistance, resistor is an integral feature. This means that all pure copper wires (which have not been distorted by their crystal structure, etc.), regardless of their shape and size, have the same resistance, but the long thin copper wire has much more resistance than a thick, short copper wire. Each material has its own characteristic resistance. For example, rubber has a much greater resistance than copper. In a hydraulic analogy, the current passing through a high-resist material is like pushing water through a pipe full of sand - while passing current through a material with low resistance, like pushing water through an empty pipe. If the pipes are the same size and shape, the pipe, full of sand, has a higher resistance to the current. Resistance, however, is not only determined by the presence or absence of It also depends on the Length and width of the pipe: Short or wide pipes have lower resistance than narrow or long pipes. The aforementioned equation can be moved to get the Pooye Law (named after Claude Pouille): R and l A . Display style of Ryo frak Ell A..., the resistance of this material is proportional to the length, but inversely proportional to the transverse area. Thus, the resistivity can be expressed by the SI ohm metre block (I·m) - i.e. ochms divided into meters (by length) and then multiplied by square meters (for the transverse area). For example, if A 1 m2, l displaystyle (ell) 1 m (forming a cube with perfectly conductive contacts on opposite faces), then the resistance of this element in the ohms numerically equals the resistance of the material, from · m. Conductivity, to, is the reverse resistiveness: Display style sigma frak {1} yo Conductivity has si units of siemens per meter (S/m). Common scalable quantities for less than ideal cases, such as more complex geometry, or when current and electric fields differ in different parts of the material, a more general expression is needed, in which resistivity at a certain point is defined as the ratio of the electric field to the current density it creates at this point: E displaystyle E is the magnitude of the electric field, J (displaystyle J) is the value of the current density in which the Estyle and J display are inside the conductor. Conductivity is the reverse (mutual) resistor. Here, it is given: No. 1 and J E . Display style sigma frak {1} x kind frak J E , For example, rubber is a material with large and small - because even a very large electric field in the rubber almost does not flow through it. On the other hand, copper is a material small and large - because even a small electric field pulls a lot of current through it. As shown below, this expression is simplified to one number when the electric field and current density are permanent in the material. The conclusion from the general definition of resistivity is there are three equations that need to be combined here. First, it is the resistiveness to the parallel current and the electric field: E J , display rho frac EJ, if the electric field is constant, the electric field is given by the general voltage of the V through the conductor, separated by the length of the L conductor: E and V (E'frac) (V'ell) Get: - V A I l (display) rho (FRAK) (VA) Iell (VAZELL) Finally, we apply the law of Om, V/I - R. It begins with the tensor-vector form of the Om act, which connects the electric field inside the material with the flow of electric current. This equation is completely general, meaning it is valid in all cases, including those mentioned above. However, this definition is the most complex, so it is only used directly in aisotropic cases where simpler definitions cannot be applied. If the material is not anisotropic, it is safe to ignore the definition of tensor vector, and use a simpler expression instead. Here anisotropic means that the material has different properties in different directions. For example, a crystal graphite consists microscopically of a stack of sheets, and the current flows very easily through each sheet, but much less easily from one sheet to the next. In such cases, the current does not flow in exactly the same direction as the electric field. Thus, ⇌ the relevant equations are summarized by the three-dimensional form of the tentor: equalizer, right-handharpons, matbf (E) These tensors can be represented by 3 x3 matrix, vectors with 3 x1 matrix, with matrix multiplication used on the right side of these equations. In matrix form, the resistivity relation is given by: [E x E y E z] = [ρ x x ρ x y ρ x z ρ y x ρ y y ρ y z ρ z x ρ z y ρ z z] [J x J y J z] {\displaystyle {\begin{bmatrix}E_{x}\\E_{y}\\E_{z}\end{bmatrix}}={\begin{bmatrix}\rho _{xx}&\rho _{xy}&\rho _{xz}\\\rho _{yx}&\rho _{yy}&\rho _{yz}\\\rho _{zx}&\rho _{zy}&\rho _{zz}\end{bmatrix}}{\begin{bmatrix}J_{x}\\J_{y}\\J_{z}\end{bmatrix}}} where E {\displaystyle \mathbf {E} } is the electric field vector, with components (Ex, Ey, Ez). The boldsymbol rho display style is a resistance tensor, usually three by three matrix. J displaystyle (mathbf) is a vector of electric current density, with components (Jx, Jy, Jz) Equivalent, resistivity can be given in Einstein's more compact notation: E i i j j'displaystyle (mathbf) (E) display style E_ xxxhehJ_ xx'he xy J_y'rho xz J_'z. E у и й й х J х й й у J у у и у z J z . display style E_'y'rho yox J_ h'howe J_ E z = ρ z x J x + ρ z y J y + ρ z z J z . «дисплейный стиль E_»зёзёхе »зкс» J_«х'х»J_ »йоу »J_»». Поскольку выбор системы координат свободен, обычная конвенция заключается в упрощении выражения, выбрав x-ось параллельно текущему направлению, так что Jy и Jz 0. Это листья: x x x x x x x x x , й й х й й й е х й й й х й й й й х й х й х й х й х й й х й х й «Дисплей-стиль ххх-фрак »E_ x»J_ x E_x, «четверка» «J_,»текст» и «зхокс»фрак (E_)»J_ Conductivity is defined similarly:[7] [J x J y J z]

= [σ x x σ x y σ x z σ y x σ y y σ y z σ z x σ z y σ z z] [E x E y E z] {\displaystyle {\begin{bmatrix}J_{x}\\J_{y}\\J_{z}\end{bmatrix}}={\begin{bmatrix}\sigma _{xx}&\sigma _{xy}&\sigma _{xz}\\\sigma _{yx}&\sigma _{yy}&\sigma _{yz}\\\sigma _{zx}&\sigma _{zy}&\sigma _{zz}\end{bmatrix}}{\begin{bmatrix}E_{x}\\E_{y}\\E_{z}\end{bmatrix}}} or J i = σ i j E j {\displaystyle \mathbf { J } _{i}={\boldsymbol {\sigma }}_{ij}\mathbf {E} _{j}} Both resulting in: J x = σ x x E x + σ x y E y + σ x z E z {\displaystyle J_{x}=\sigma _{xx}E_{x}+\sigma _{xy}E_{y}+\sigma _{xz}E_{z}} J y = σ y x E x + σ y y E y + σ y z E z {\displaystyle J_{y}=\sigma _{yx}E_{x}+\sigma _{yy}E_{y}+\sigma _{yz}E_{z}} J z = σ z x E x + σ z y E y + σ z z E z {\displaystyle J_{z}=\sigma _{zx}E_{x}+\sigma _{zy}E_{y}+\sigma _{zz}E_{z}} Looking at the two expressions, ρ {\displaystyle {\boldsymbol {\rho }}} and σ {\displaystyle {\boldsymbol {\sigma }}} are the matrix inverse of each other. Однако в самом общем случае отдельные элементы матрицы не обязательно являются взаимными друг от друга; например, xxc не может быть равен 1/йкс. Это можно увидеть в эффекте Зала, где х й й й »дисплей »rho »xy» является незеро. In the Hall effect, due to rotational invariance about the z-axis, ρ y y = ρ x x {\displaystyle \rho _{yy}=\rho _{xx}} and ρ y x = − ρ x y {\displaystyle \rho _{yx}=-\rho _{xy}} , so the relation between resistivity and conductivity simplifies to:[8] σ x x = ρ x x ρ x x 2 + ρ x y 2 , σ x y = − ρ x y ρ x x 2 + ρ x y 2 {\displaystyle \sigma _{xx}={\frac {\rho _{xx}}{\rho _{xx}^{2}+\rho _{xy}^{2}}},\quad \sigma _{xy}={\frac {-\rho _{xy}}{\rho _{xx}^{2}+\rho _{xy}^{2}}}} If the electric field is parallel to the applied current, ρ x y {\displaystyle \rho _{xy}} and ρ x z {\displaystyle \rho _{xz}} are zero. Когда они ноль, одного числа, x x x «дисплей» (rho xx), достаточно, чтобы описать электрическую резисторию. Затем она пишется как просто «дисплей »rho », и это сводится к более простому выражению. Проводимость и текущие носители Связь между плотностью тока и электрическим током скорости Электрический ток является упорядоченным движением электрических зарядов. Эти сборы называются текущими перевозчиками. В металлах и полупроводниках электроны являются electrolytes and ionized ions, positive and negative ions. In general, the current density of a single carrier is determined by the formula: j q n'a, where n is the density of the charge carriers (the number of carriers in the volume of the unit), q is a charge of one carrier, Vec upsilon display is the average speed of their movement. If the current consists of many J and ∑ J j displaystyle (vec) j'sum (j'j) j_i. . where j i displaystyle j_i is the current density of i 'displaystyle i' - the carrier. Reasons for Band conduction theory have simplified See. also: The theory of band Filling electronic states in different types of materials in balance. Here, height is energy, while width is the density of available states for certain energy in the material listing. The shadow follows the distribution of Fermi-Dirac (black - all states are filled, white - no filled state). In metals and semi-metals, the Fermi EF level is located inside at least one band. In insulators and semiconductors, Fermi's level is inside the lane gap; however, in semiconductors, the strips are close enough to The Fermi level to be thermally populated by electrons or holes. Edit According to elementary quantum mechanics, an electron in an atom or crystal can only have certain precise energy levels; energy between these levels is impossible. When a large number of such permitted levels have a close space of energy values, i.e. energy that differs only for a minute, these close energy levels are combined to be called the energy band. There may be many such energy bands in the material, depending on the atomic number of composite atoms and their distribution inside the crystal. The electrons of the material aim to minimize the total energy in the material, settling in a low-energy source; however, the principle of Pauli's exclusion means that there can only be one in each state. Thus, electrons fill the structure of the strip, starting from below. The characteristic energy level to which the electrons are filled is called Fermi level. The position of The Fermi level in relation to the structure of the band is very important for electrical conduction: only electrons in energy levels near or above The Fermi level can move freely within a wider material structure, as electrons can easily jump between partially occupied states in the region. In contrast, low energy states are completely filled with a fixed limit on the number of electrons at all times, and high energy states will be empty electrons at all times. The electric current consists of a stream of electrons. The metals have many levels of electron energy near The Fermi level, so there are many electrons available to move. Exactly causes high electronic conductivity Metals. An important part of the band theory is that energy bands may be banned: energy intervals that do not contain energy levels. In insulators and semiconductors, the number of electrons is just the right amount to fill a particular integer number of low energy bands, exactly to the border. In this case, the Fermi level falls into the lane break. Because there are no available states near The Fermi level, and electrons are not mobile freely, electronic conductivity is very low. In Metals Main Article: Free Electronic Model Like Balls in Newton's Cradle, electrons in metal quickly transfer energy from one terminal to another, despite their own insignificant movement. The metal consists of a lattice of atoms, each of which has an outer shell of electrons that are free to disassociate themselves from their parent atoms and travel through the lattice. This is also known as the positive ionical lattice. This sea of disparate electrons allows the metal to conduct an electric current. When an electrical potential difference (voltage) is applied through metal, the resulting electric field causes the electrons to drift towards the positive terminal. The actual rate of electron drift is usually small, at an order of magnitude per hour. However, due to the sheer number of moving electrons, even the slow drift rate leads to a high current density. The mechanism is similar to the transmission of pulse balls in Newton's cradle, but the rapid spread of electrical energy along the wire is not due to mechanical forces, but because of the spread of the energy-carrying electromagnetic field controlled by the wire. Most metals have electrical resistance. In simpler models (not quantum-mechanical models) this can be explained by the replacement of electrons and crystal lattice by a wave-shaped structure. When an electron wave passes through the grate, the waves interfere, causing resistance. The more regular the grille, the less perturbation occurs and therefore less resistance. Thus, the amount of resistance is mainly caused by two factors. First, it is caused by temperature and therefore the amount of vibration of the crystal lattice. Higher temperatures cause large vibrations that act as irregularities in the grille. Secondly, the purity of the metal is relevant, as the mixture of different ions is also uneven. A slight decrease in the conduction of pure metals is associated with the loss of long-range crystalline order. The order of the short range remains, and a strong correlation between the positions of the ions leads to consistency between the waves separated by neighboring ions. In semiconductors and insulators Main articles: Semiconductor and Insulator (electricity) In metals, Fermi level lies within the conduction range (see Band Theory, that generates free conductivity electrons. However, in semiconductors, the fermi Fermi level strip clearance, about halfway between the minimum conduction band (the bottom of the first band of unfilled electron energy levels) and the maximum band of valence (the upper part of the band under the conduction band, filled electron energy levels). This also applies to internal (unsalted) semiconductors. This means that at absolute zero temperature there will be no free conductivity electrons, and resistance is infinite. However, resistance decreases as the density of the charge carrier increases (i.e. without further complications, electron density) within the conduction range. In external (doping) semiconductors, pre-pant atoms increase the concentration of the majority carrier by sacrificing electrons in the conductivity band or producing holes in the valence range. (A hole is a position where there is no electron; such holes can behave in the same way as electrons.) For both types of donor or accepter atoms, increasing the density of additionals reduces resistance. Thus, semiconductors with high doping behave metallically. At very high temperatures, the contribution of heat-generated carriers dominates the contribution of the pre-pant atoms, and resistance decreases exponentially with temperature. In ion fluids/electrolytes The main article: Conductivity (electrolytic) In electrolytes electrical conductivity occurs not by electrons of stripes or holes, but by full atomic species (ion), each of which carries an electric charge. Resistance to ion solutions (electrolytes) varies greatly depending on concentration - while distilled water is almost insulated, salt water is a reasonable electric conductor. Conductivity in ion fluids is also controlled by the movement of ions, but here we are talking about molten salts, not permitted ions. In the biological membranes of the toki revenge ion salts. Small holes in cell membranes, called ion channels, are selective for specific ions and determine the stability of the membrane. The concentration of ions in the liquid depends on the degree of dissociation charged by the dissociation factor, which is determined by the concentration of N displaystyle N ions to the concentration of dissolved substance N 0 displaystyle N_{0} N_{0}. The specific electrical conductivity of the solution is equal to σ = q (b + + b −) α N {\displaystyle \sigma =q\left(b^{+}+b^{-}\right)\alpha N} , where q {\displaystyle q} : module of the ion charge, b + {\displaystyle b^{+}} and b − {\displaystyle b^{-}} : mobility of positively and negatively charged ions, N {\displaystyle N} : ion concentration, α {\displaystyle \alpha } : the coefficient of dissociation. Superconductivity Home article: Superconductivity Electricalness of the Metal Conductor gradually decreases as temperature In conventional conductors, such as copper or silver, this decrease is limited to impurities and other defects. Even near absolute zero, a real sample of a normal conductor shows some resistance. In the superconductor, resistance drops sharply to zero when the material cools below critical temperature. The electric current flowing into the superconducting wire can be stored indefinitely without a power source. In 1986, researchers found that some coendra-perovskite ceramic materials had much higher critical temperatures, and in 1987 one of them was produced at a critical temperature above 90 K (183 degrees Celsius). Such a high transition temperature is theoretically impossible for a conventional superconductor, so the researchers named these conductors high-temperature superconductors. Liquefied nitrogen boils at 77 K, cold enough to activate high-temperature superconductors, but not cold enough for conventional superconductors. In conventional superconductors, electrons are held together in pairs of attraction mediated by phonons of lattice. The best available high-temperature superconductor model is still somewhat crude. There is a hypothesis that the pairing of electrons in high-temperature superconductors is mediated by short-range spin waves known as paramagnones. (questionable - discuss) Plasma main article: Plasma (physics) Lightning is an example of plasma present on the Earth's surface. Lightning typically discharges 30,000 amps at an altitude of up to 100 million volts and emits light, radio waves and X-rays. The plasma temperature in lightning can be closer to 30,000 kelvins (29,727 degrees Celsius) (53,540 degrees Fahrenheit), or five times hotter than the temperature on the Sun's surface, and the electron density can exceed 1,024 m/3. Plasmas are very good conductors and electrical potentials play an important role. The potential as it exists in the middle space between charged particles, regardless of the question of how it can be measured, is called plasma potential, or cosmic potential. If an electrode is inserted into a plasma, its potential usually lies well below plasma potential, due to what is called the Debye shell. Good electrical conductivity of plasma makes their electric fields very small. This leads to an important quasi-negativeization concept, which says that the density of negative charges is roughly equal to the density of positive charges over large volumes of plasma (ne no ⟨'⟩ni), but the scale of the length of Debye may be a charge imbalance. In a special case, when double layers are formed, the separation of the charge can extend several dozen Debye lengths. The scale of potentials and electric fields should be determined not just by searching n_ texte-propo e-k_text T_ text. The differentiation of this relationship provides a means to calculate the electric field from density: E q k B T e e e e ∇ n e n e e e. Display-style (mathematical) (E) Frak k_ text B T_ text and frak (abla n_) text, text n_ text. (∇ vector gradient operator; see nabla symbol and gradient for more information.) It is possible to produce plasma that is not a quasi-neutral. The electronic beam, for example, has only negative charges. The density of non-neutral plasma should usually be very low, or it should be very small. Otherwise, the repulsive electrostatic force dissipates it. In astrophysical plasma, Debye screening prevents the direct effects of electric fields on plasma over long distances, i.e. longer than the length of Debye. However, the existence of charged particles leads to the fact that plasma generates magnetic fields and it is affected. This can and does cause extremely complex behaviors, such as the generation of double layers of plasma, an object that separates the charge by several dozen debye lengths. The dynamics of plasmas interacting with external and self-generated magnetic fields are studied in the academic discipline of magnetohydrodynamics. Plasma is often called the fourth state of matter after solid liquids and gases. It differs from these and other low-energy states of matter. Although it is closely related to the gas phase in that it also does not have a certain shape or volume, it differs in a number of ways, including the following: The Property Strip Plasma Electrical Conduction is very low: air is an excellent insulator until it breaks down into plasma on an electric field of strengths above 30 kilovolts per centimeter. Usually very high: for many purposes, plasma conduction can be considered as infinite. Independent appearance One: all gas particles behave in this way, under the influence of gravity and collisions with each other. Two or three: electrons, ions, protons and neutrons can be distinguished by the sign and significance of their charge so that they behave independently in many circumstances, with different speeds and temperatures, allowing for phenomena such as new types of waves and instability. Maxwellian speed distribution: collisions usually result in the distribution of Maxwellian speed of all gas particles, with very few relatively fast particles. Often not Maxwellian: collisions are often weak in hot plasmas, and external influence can cause plasma far from local equilibrium and lead to a significant population of unusually fast particles. Interactions are binary: collisions of two particles are the rule, collisions of three bodies are extremely rare. Collective: waves, or organized plasma movement, are very important because particles can interact over long distances electrical and magnetic forces. Resistance and Of various materials The main article: Electrical resistor elements (data page) Explorer, such as metal has high conductivity and low resistor. The insulator as glass has low conductivity and high resistor. Semiconductor conductivity is usually intermediate, but varies widely under different conditions, such as the impact of the material on electrical fields or specific frequencies of light, and, most importantly, with the temperature and composition of the semiconductor material. The degree of semiconductor doping is of great importance in conductivity. At some point, more doping leads to higher conductivity. The conduction of the water solution strongly depends on the concentration of dissolved salts and other chemical species, which are ionized in the solution. The electrical conduction of water samples is used as an indicator of how salt-free, without ion or without impurities is a sample; the cleaner the water, the lower the conductivity (the higher the resistor). Measurements of conductivity in water are often reported as specific conductivity, relative to the conductivity of clean water at 25 degrees Celsius. The EC meter is commonly used to measure conductivity in a solution. A rough summary is as follows: Material Resistivity, ρ (Ω·m) Superconductors 0 Metals 10−8 Semiconductors Variable Electrolytes Variable Insulators 1016 Superinsulators ∞ This table shows the resistivity (ρ), conductivity and temperature coefficient of various materials at 20 °C (68 °F, 293 K) Material Resistivity, ρ (Ω·m) at 20 °C Conductivity, σ (S/m) at 20 °C Temperature coefficient[c] (K−1) Reference Silver[d] 1.59×10−8 6.30×107 0.00380 [23][24] Copper[e] 1.68×10−8 5.96×107 0.00404 [25][26] Annealed copper[f] 1.72×10−8 5.80×107 0.00393 [27] Gold[g] 2.44×10−8 4.11×107 0.00340 [23] Aluminium[h] 2.65×10−8 3.77×107 0.00390 [23] Calcium 3.36×10−8 2.98×107 0.00410 Tungsten 5.60×10−8 1.79×107 0.00450 [23] Zinc 5.90×10−8 1.69×107 0.00370 [28] Cobalt[i] 6.24×10−8 1.60×107 0.007[30][unreliable source?] Nickel 6.99×10−8 1.43×107 0.006 Ruthenium[i] 7.10×10−8 1.41×107 Lithium 9.28×10−8 1.08×107 0.006 Iron 9.70×10−8 107 0.005 [23] Platinum 1.06×10−7 9.43×106 0.00392 [23] Tin 1.09×10−7 9.17×106 0.00450 Gallium 1.40×10−7 7.10×106 0.004 Niobium 1.40×10−7 7.00×106 [31] Carbon steel (1010) 1.43×10−7 6.99×106 [32] Lead 2.20×10−7 4.55×106 0.0039 [23] Galinstan 2.89×10−7 3.46×106 [33] Titanium 4.20×10−7 2.38×106 0.0038 Grain oriented electrical steel 4.60×10−7 2.17×106 [34] Manganin 4.82×10−7 2.07×106 0.000002 [35] Constantan 4.90×10−7 2.04×106 0.000008 [36] Stainless steel[j] 6.90×10−7 1.45×106 0.00094 [37] Mercury 9.80×10−7 1.02×106 0.00090 [35] Manganese 1.44×10−6 6.94×105 Nichrome[k] 1.10×10−6 6.70×105[citation needed] 0.0004 [23] Carbon (amorphous) to 8-10-4 1.25-103- 2.00-103 (0.0005) carbon (graphite) parallel bass plane up to 5.0-10-6 2-105 to 3-105 (required citation) Carbon (graphite) perpendicular to base plane 3'10'3 3'102 (4) GAAs 1 from 0 to 108 10 to 103 (39) Germany 4.6-10-1 2.2 17 (0.048) Water in the swimming pool No 1 4.8 (40) from 3.3 to 4.0-10.10-1 0.25 - 0.30 (41) Drinking water from 101 to 2' 103 5'10'4 to 5'10'2 'quoting essential' Silicon m 2.3'103 4.35'10'4 0.075 42 Wood (wet) 10 from 3 to 104 from 10 to 10-3 (43) Deionized Water 1.8-105 5.5-10-6 Glass 1011 - 1015 10-15 - 10-11? Carbon (diamond) 1012 (10-13) Solid rubber 1013 10-14 ? Air from 109 to 1015 from 10-15 to 10-9 (46) Wood (baking dry) 1014 - 1016 10-16 - 10-14 (43) Sulfur 1015 10-16? Fused quartz 7.5'1017 1.3'10'18 ? PET 1021 10-21? Teflon 1023 to 1025 from 10 to 25 to 10-23? The effective temperature factor varies depending on the temperature and purity of the material. The value of 20 degrees Celsius is only approximation when used at other temperatures. For example, the ratio is lower at higher copper temperatures, and 0.00427 is usually 0 degrees Celsius. George Gamow neatly summed up the nature of the relationship between metals and electrons in his non-fiction book One, Two, Three... Infinity (1947): Metallic substances differ from all other materials in that the outer shells of their atoms are connected quite freely, and often allow one of their electrons to be released. Thus, the inside of the metal is filled with a large number of unattached electrons that travel aimlessly around like a crowd of displaced persons. More technically, the free electron model gives a basic description of the flow of electrons in metals. Wood is widely regarded as a very good insulator, but its resistance is sensitive to moisture content, with moist wood being a factor of at least 1010 worse insulators than a dry oven. In any case, high enough voltage, for example, when struck by lightning or some high-voltage power lines, can lead to the breakdown of insulation and the risk of electric shock even in obviously dry wood. (quote necessary) Temperature dependence Linear approximation Electrical resistor of most materials varies with temperature. If T's temperature isn't much different, a linear approximation is usually used: T and T where display {0} 1 (T-T_{0}), where alpha display The resistance factor, T 0 displaystyle T_{0} is a fixed reference temperature (usually room temperature), and No. 0 displaystyle rho {0} is resistorative at T 0 displaystyle T_{0}. The display is an empirical setting based on measurements. Because the linear approximation is only an approximation, the alpha display differs for different reference temperatures. For this reason, it is customary to specify the temperature at which the suffix was measured, for example, on the suffix, for example, at 1 {15}5 euros, and the connection is held only in the temperature range around the link. When the temperature changes over a large temperature range, the linear approximation is insufficient and more detailed analysis and understanding should be used. Metals See also: Bloch-Gr'neisen temperature and free electronic model - Average dependence of free temperature trajectory of resistance of gold, copper and silver. In general, the electrical resistance of metals increases with temperature. Electron-phonon interactions can play a key role. At high temperatures, metal resistance increases linearly with temperature. As the metal temperature drops, the temperature resistance dependence follows the function of the power law temperature. The mathematical temperature dependence of metal resistance is given by the Formula Bloch-Grunaysen: No (T) No (0) - A (T Θ R) N ∫ 0 Θ R T x n (e q 1) (1 - e q x) d Left (1 - e q x) Frac (TETA) (right) and int ({0})-frak (e-1-1) left (1st-x-x) left (1st-x-x) left (1-x-x) (1-x) ,dx, where q (0) displaystyle rho (0) is a residual resistivity due to scattering defects A is a constant that depends on the speed of electrons on the surface of Fermi, the radius of Debye and the density of electrons in metal. Θ R (Theta) is the Debye temperature derived from resistive measurements and very closely aligned with Debye's temperature values derived from specific heat measurements. n is an integrator that depends on the nature of the interaction: n No. 5 implies that resistance is due to the scattering of electrons by phonon (as well as for simple metals) n No. 3 implies that resistance is associated with electron scattering (as in the case of transient metals) n No 2 implies that resistance is associated with electron-electronic interaction. If there is more than one source of scattering at the same time, the Mattissen Rule (first formulated by August Mattissen in the 1860s) argues that general resistance can be approximated by adding several different terms, each of which has an appropriate n. Because the temperature of the metal is sufficiently reduced (to freeze everything rhesonance usually reaches a constant value known as residual resistment. This value depends not only on the type of metal, but also on its purity and thermal history. The value of the metal's residual resistance is decided by its concentration of impurities. Some materials lose all electrical resistor at fairly low temperatures, due to an effect known as superconductivity. The study of low-temperature metal resistance was the motivation for the experiments of Heiko Camerling Onnes, which led to the discovery of superconductivity in 1911. Read more about the history of superconductivity in history. The Wiedemann-Franz Act states that the electrical conduction ratio of metals at normal temperatures is inversely proportional to the temperature of 52: ∼ 1 T displaystyle sigma thicksim 1 over T . At high metal temperatures, Wiedemann-Franz's law holds: K q No 2 3 (k e) 2 T displaystyle K over sigma pi{2} over 3 left (frac ke'right) {2}T , where K displaystyle K Bolt is constant, e display e: electronic charge, T displaystyle T: temperature, display Semiconductors Main article: Semiconductor In general, the internal resistance of semiconductors decreases with the increase in temperature. Electrons run into the energy group of conductivity with thermal energy, where they flow freely, and at the same time leave holes in the valence band, which also flow freely. The electrical resistance of a typical internal (non-doping) semiconductor is exponentially reduced with temperature: 0 e - T (display) yo you ({0}e'-aT) , even better approximation of the temperature dependence of semiconductor resistance is given by the Steinhart equation Hart: 1 T - A - B ln q C (ln) 3 (display style) frac {1}T'A'B'ln s'rho q (ln'rho) {3} where odds A, B and C are the so-called Steinhart-Hart coefficients. This equation is used to calibrate the thermostorors. External (doping) semiconductors have a much more complex temperature profile. As temperatures rise from absolute zero, they initially drop sharply in resistance as carriers leave donors or accepters. Once most donors or adopters have lost their carriers, the resistance begins to increase slightly due to reduced media mobility (just as in metal). At higher temperatures, they behave like internal semiconductors, as carriers from donors/receivers become insignificant compared to heat-generated carriers. In non-crystal semiconductors, the behavior can occur at the expense of quantum tunnel charges from one localized area to another. It is known as the variable jump range and has a distinctive shape (T No 1 n), Rho A'exp display on the left (TK-frak {1} on the right), where n No. 2, 3, 4, depending on the dimension of the system. Complex resistority and conductivity When analyzing the reaction of materials to alternating electric fields (dielectric spectroscopy) in applications such as electric tomography, it is convenient to replace resistivity with a complex amount called impulsivity (similar to electrical impulse). Impulsiveness is the sum of the real component, resistivity and imaginary component, reactivity (similar to the reaction). The magnitude of impulsivity is a square root of the sum of squares of resistance and reactivity. Conversely, in such cases conductivity should be expressed as a complex number (or even as a matrix of complex numbers, in the case of anisotropic materials), called tolerance. Recognition is the sum of a real component called conductivity and an imaginary component called susceptibility. An alternative description of the reaction to variable currents uses real (but frequency-dependent) conductivity, along with real tolerance. The more conductivity, the faster the alternating current is absorbed by the material (i.e. the more opaque the material is). For more information, see Mathematical descriptions of opacity. Resistance against resistance in complex geometries, even if the resistance of the material is known, the calculation of resistance of something from it can, in some cases, be much more difficult than the formula R and l /A displaystyle R'rho ell /A above. One example is the spread of resistance profiling, where the material is heterogeneous (different resistance in different places), and the exact paths of the current flow are not obvious. In such cases, Formula J and E ⇌ E and J (display J'sigma E',','rightleftharpoons,'e'rho J',)e'rho J', should be replaced by J ⇌ (r) ((Matebf (r))) Sigma (Matebf (p)) (Matebf (Matt) along with the continuity equation for J and the Poisson equation for E, form a set of partial differential equations. In special cases, the exact or approximate solution to these equations can be manually designed, but very accurate responses in complex cases may require computer-generated methods, such as analysis of the final elements. Resistivity-density product In some applications where the weight of the item is very important, the product of resistivity and density is more important than the absolute low resistivity - it is often possible to make the conductor thicker to make your account a higher resistivity; and then material (or equivalent to a high power-to-density ratio) is desirable. For example, long-distance overhead transmission lines often use aluminium rather than copper because it is easier for the same conductivity. Silver, although it is the least resistant metal known, has a high density and performs similarly to copper on this indicator, but much more expensive. Calcium and alkaline metals have the best density resistance products, but are rarely used for conductors because of their high reactivity with water and oxygen (and lack of physical strength). Aluminium is much more stable. Toxicity precludes the choice of beryllium. (Clean beryllium is also fragile.) Thus, aluminum is usually the metal of choice when the weight or cost of the conductor is the driving factor. Material Resistivity (nΩ·m) Density (g/cm3) Resistivity × density Volume, relative to Cu, giving same conductance Mass, relative to Cu, giving same conductance Approx. price (USD per kg) (9 December 2018)[citation needed] Approx. price relative to Cu (g·mΩ/m2) Relative to Cu Sodium 47.7 0.97 46 31% 2.843 0.31 Lithium 92.8 0.53 49 33% 5.531 0.33 Calcium 33.6 1.55 52 35% 2.002 0.35 Potassium 72.0 0.89 64 43% 4.291 0.43 Beryllium 35.6 1.85 66 44% 2.122 0.44 Aluminium 26.50 2.70 72 48% 1.5792 0.48 2.0 0.16 Magnesium 43.90 1.74 76 51% 2.616 0.51 Copper 16.78 8.96 150 100% 1 1 6.0 1 Silver 15.87 10.49 166 111% 0.946 1.11 456 84 Gold 22.14 19.30 427 285% 1.319 2.85 39,000 19,000 Iron 96.1 7.874 757 505% 5.727 5.05 See also Charge transport mechanisms Chemiresistor Classification of materials based on permittivity Conductivity near the percolation threshold Contact resistance Electrical resistivities of the elements (data page) Electrical resistivity tomography Sheet resistance SI электромагнетизм единиц эффект кожи Спитцер резистенционность Примечания - атомное число является число электронов в атоме which is electrically neutral - has no pure electric charge. Other relevant factors that are not specifically considered are the size of the entire crystal and external environmental factors that alter energy bands, such as imposed electrical or magnetic fields. The numbers in this column increase or decrease the significand part of the resistor. For example, at 30 degrees Celsius (303 K), silver is 1.65-10-8. This is calculated as z. z, where the zo is resystenable at 20 degrees Celsius (in this case) and is a temperature factor. The conductivity of metal silver is not much better than metal copper for most practical purposes - the difference between them can be easily compensated by thickening copper wire by only 3%. However, silver is preferable to open electrical contact points because corroded silver is tolerable but corrosive copper is a pretty good insulator as corrosive metals. Copper is widely used in electrical equipment, building wiring and telecommunications cables. It is called 100% MAKS or the International Copper quality standard. The device to express the conduction of non-magnetic materials by testing using the current method of eddy. Usually used to test the temperament and alloy of aluminum. Although gold is less conductable than copper, it is commonly used in electrical contacts because it does not corrode easily. - Usually used for overhead power lines with steel reinforced (ACSR) - b Cobalt and ruthenium are considered to be replacement copper in integrated circuits manufactured in advanced nodes, 18% chromium and 8% nickel austenic stainless steel - nickel-iron-chromium alloy, commonly used in heating elements. Graphite is very anisotropic. b Semiconductor resistance depends heavily on the presence of impurities in the material. It corresponds to an average salinity of 35 g/kg at 20 degrees Celsius. The rn should be about 8.4 and conductivity in the range of 2.5-3 mC/cm. Lower value is suitable for freshly prepared water. Conductivity is used to determine TDS (full dissolved particles). This range of values is typical of high-quality drinking water, not an indicator of water quality - conductivity is the lowest with monotomic gases; changes to 12-10-5 with complete de-gasification, or up to 7.5-10-5 when equilibrium into the atmosphere due to dissolved CO2 Links - Lowry, William (2007). The basics of geophysics. Cambridge University Press. 254-55. ISBN 978-05-2185-902-8. Received on March 24, 2019. Kumar, Narinder (2003). Comprehensive Physics for Class XII. New Delhi: Laxmi Publications. 280-84. ISBN 978-81-7008-592-8. Received on March 24, 2019. Bogatin, Eric (2004). Signal integrity: Simplified. Prentice Hall Professional. page 114. ISBN 978-0-13-066946-9. Received on March 24, 2019. a b c Hugh O. Pierson, Handbook on Carbon, Graphite, Diamond and Fullerenes: Properties, Processing and Application, page 61, William Andrew, 1993 ISBN 0-8155-1339-9. J.R. 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