ELECTRON INELASTIC MEAN FREE PATHS

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The inelastic mean free path (IMFP) of electrons is defined as the average of distances, measured along the trajectories, that electrons with a given energy travel between inelastic collisions in the substance. It is an important parameter in analyzing results from surface-characterization techniques such as Auger electron spectroscopy, x-ray photoelectron spectroscopy, low-energy electron diffraction, and others. IMFPs can be measured by the elastic-peak electron spectroscopy technique and other methods, and they can be calculated from optical data. A detailed analysis of the experimental and theoretical considerations in obtaining reliable IMPF values can be found in reference 4.

The table below gives recommended IMFP values for several elements, simple inorganic compounds, and organic materials. Values are given in Ångström units (1 Å = 10^{-10} m) for a range of electron energies. Substances are given in alphabetical order by name, with elements and inorganic compounds listed before the organic materials.

References

1. Tanuma, S., Powell, C. J., and Penn, D. R., *Surf. Interface Anal.* 17, 911, 1991.
2. Tanuma, S., Powell, C. J., and Penn, D. R., *Surf. Interface Anal.* 17, 927, 1991.
3. Tanuma, S., Powell, C. J., and Penn, D. R., *Surf. Interface Anal.* 21, 165, 1994.
4. Powell, C. J., and Jablonski, A., *J. Phys. Chem. Ref. Data* 28, 19, 1999.
5. Tanuma, S., Powell, C. J., and Penn, D. R., *Surf. Interface Anal.*, 37, 1, 2005.

Electron Inelastic Mean Free Path in Å

Electron Energy in eV

Substance	Formula	50	100	150	200	300	400	600	800	1000	1200	1400	1600	1800	2000	Ref.
Aluminum	Al	3.5	4.6	5.7	6.8	8.9	10.9	14.5	18.0	21.3	24.6	27.8	31.0	34.1	37.2	5
Bismuth	Bi	4.9	5.5	6.3	7.2	8.8	10.6	14.0	17.2	20.2	23.2	26.1	28.9	31.6	34.4	1
Carbon	C	5.9	6.4	7.5	8.8	11.2	13.7	18.4	22.8	27.0	31.1	35.2	39.1	43.0	46.8	1
Chromium	Cr	4.4	4.3	5.0	5.7	7.2	8.6	11.4	14.0	16.6	19.1	21.6	24.0	26.3	28.6	1
Copper	Cu	5.2	5.0	5.4	6.0	7.3	8.6	11.3	13.9	16.5	18.9	21.3	23.7	26.0	28.3	4
Gallium phosphide	GaP	5.6	6.5	7.8	9.0	11.4	13.7	18.1	22.3	26.3	30.2	34.1	37.8	41.5	45.2	2
Gold	Au	6.3	4.7	4.7	5.1	6.1	7.2	9.5	11.7	13.8	15.8	17.8	19.7	21.6	23.4	4
Hafnium	Hf	5.8	6.2	7.1	8.0	10.2	12.0	15.6	19.0	22.2	25.3	28.4	31.4	34.4	37.3	1
Indium phosphide	InP	4.8	4.9	5.6	6.4	8.1	9.7	12.8	15.7	18.7	21.4	24.2	26.8	29.4	32.0	2
Iridium	Ir	5.3	4.3	4.7	5.2	6.4	7.5	9.7	11.8	13.8	15.7	17.6	19.4	21.2	22.9	1
Iron	Fe	4.3	4.4	5.1	5.8	7.2	8.5	11.2	13.7	16.2	18.6	20.9	23.2	25.5	27.7	1
Lead(II) sulfide	PbS	4.8	5.6	6.7	7.8	10.0	12.1	16.1	19.8	23.6	27.1	30.6	33.9	37.2	40.5	2
Lead(II) telluride	PbTe	4.3	5.5	6.6	7.7	9.8	11.9	15.8	19.6	23.4	26.9	30.3	33.7	37.0	40.2	2
Magnesium	Mg	4.0	5.4	6.8	8.2	10.7	13.0	17.5	21.7	25.9	29.9	33.9	37.7	41.6	45.3	1
Molybdenum	Mo	5.1	4.5	5.0	5.6	7.1	8.5	11.3	14.0	16.5	18.9	21.2	23.5	25.8	28.0	1
Nickel	Ni	4.9	4.5	4.9	5.4	6.5	7.7	10.1	12.4	14.6	16.7	18.8	20.8	22.8	24.7	4
Niobium	Nb	6.0	6.0	6.7	7.7	9.7	11.7	15.6	19.2	22.6	25.9	29.1	32.3	35.3	38.4	1
Osmium	Os	5.5	4.3	4.5	5.0	6.0	7.1	9.1	11.1	12.9	14.7	16.4	18.1	19.8	21.5	1
Palladium	Pd	4.8	4.8	5.4	6.2	7.8	9.4	12.5	15.4	18.2	20.9	23.5	26.0	28.4	30.9	1
Platinum	Pt	5.0	4.2	4.5	4.9	6.0	7.1	9.2	11.2	13.1	14.9	16.7	18.5	20.2	21.9	1
Potassium chloride	KCl	7.5	7.8	9.3	10.9	14.2	17.3	23.2	28.7	34.0	39.2	44.2	49.1	54.0	58.8	2
Rhenium	Re	5.2	3.8	3.9	4.3	5.1	6.0	7.7	9.4	10.9	12.5	14.0	15.4	16.9	18.3	1
Rhodium	Rh	4.8	4.1	4.5	5.0	6.1	7.3	9.7	12.0	14.1	16.2	18.2	20.1	22.0	23.9	1
Ruthenium	Ru	4.9	4.2	4.6	5.2	6.5	7.8	10.4	12.8	15.1	17.4	19.5	21.6	23.7	25.7	1
Silicon	Si	4.1	5.3	6.5	7.8	10.3	12.5	16.6	20.6	24.4	28.2	31.8	35.4	39.0	42.5	1
Silicon carbide	SiC	4.7	4.9	5.8	6.8	8.7	10.5	13.9	17.1	20.3	23.3	26.3	29.2	32.1	35.0	2
Silicon dioxide (vitreous)	SiO_2	8.0	7.7	8.8	10.0	12.6	15.2	20.0	24.7	29.3	33.7	38.0	42.2	46.4	50.5	2
Silver	Ag	6.4	4.7	4.8	5.2	6.4	7.7	10.2	12.6	14.9	17.2	19.3	21.4	23.5	25.5	4
Tantalum	Ta	4.8	4.5	5.0	5.5	6.8	8.0	10.4	12.7	14.8	16.9	19.0	21.0	22.9	24.9	1
Titanium	Ti	4.5	5.1	6.2	7.3	9.5	11.6	15.6	19.5	23.2	26.8	30.2	33.6	36.9	40.2	1
Tungsten	W	5.0	4.1	4.5	5.0	6.1	7.3	9.4	11.4	13.4	15.2	17.1	18.9	20.6	22.4	1
Vanadium	V	4.2	4.9	5.9	6.8	8.8	10.7	14.3	17.7	21.0	24.3	27.4	30.5	33.5	36.4	1
Yttrium	Y	5.0	5.5	6.4	7.5	9.8	11.9	16.0	19.8	23.4	27.0	30.4	33.8	37.1	40.4	1
Zinc sulfide	ZnS	5.8	6.5	7.7	8.9	11.3	13.6	17.9	22.0	26.0	29.8	33.6	37.3	40.9	44.5	2
Zirconium	Zr	4.4	4.8	5.7	6.6	8.6	10.5	14.1	17.5	20.7	23.8	26.9	29.9	32.8	35.7	1
Adenine	$C_5H_5N_5$	6.4	6.6	7.8	9.2	11.8	14.4	19.2	24.1	28.6	33.1	37.4	41.6	45.8	49.9	3
Bovine plasma albumin		7.3	7.2	8.5	9.9	12.7	15.4	20.7	25.8	30.8	35.6	40.2	44.8	49.4	53.8	3
β-Carotene	$C_{40}H_{56}$	6.4	7.0	8.5	10.0	13.0	15.9	21.4	26.9	32.0	37.0	41.9	46.6	51.3	56.0	3

Substance	Formula	50	100	150	200	300	400	600	800	1000	1200	1400	1600	1800	2000	Ref.
Deoxyribonucleic acid (DNA)		7.3	7.3	8.5	9.8	12.6	15.4	20.7	25.9	30.8	35.6	40.3	44.9	49.4	53.8	3
1,6-Diphenyl-1,3,5-hexatriene	$C_{18}H_{16}$	6.4	7.0	8.4	9.9	12.9	15.8	21.3	26.7	31.8	36.8	41.7	46.4	51.1	55.7	3
Guanine	$C_5H_5N_5O$	6.2	6.2	7.2	8.4	10.8	13.1	17.5	21.8	25.9	29.9	33.8	37.6	41.4	45.1	3
Hexacosane	$C_{26}H_{54}$	7.0	7.6	9.2	10.9	14.1	17.2	23.2	29.2	34.7	40.1	45.4	50.6	55.7	60.7	3
Kapton		7.0	6.8	7.9	9.2	11.7	14.2	19.0	23.7	28.2	32.5	36.7	40.9	44.9	49.0	3
Polyacetylene		5.3	5.7	6.8	7.9	10.2	12.5	16.9	21.1	25.1	29.0	32.8	36.5	40.2	43.8	3
Poly(butene-1-sulfone)		7.1	7.2	8.5	9.9	12.7	15.4	20.7	25.8	30.6	35.3	39.9	44.4	48.8	53.2	3
Polyethylene		6.9	7.2	8.6	10.1	13.0	15.9	21.4	26.8	31.8	36.8	41.6	46.3	51.0	55.6	3
Poly(methyl methacrylate)		7.8	7.9	9.3	10.8	13.9	16.9	22.7	28.3	33.7	38.8	43.9	48.9	53.8	58.6	3
Polystyrene		6.9	7.3	8.7	10.2	13.2	16.1	21.6	27.1	32.2	37.2	42.1	46.9	51.6	56.2	3
Poly(2-vinylpyridine)		6.9	7.3	8.7	10.3	13.3	16.2	21.8	27.3	32.5	37.5	42.4	47.3	52.0	56.7	3