

W Values

A “W” value is the energy deposition in a gas required to produce “an event” such as ionization or excitation. A large W-value implies that the process is less efficient than one with a small W-value because more energy is required to produce the event. The W-value is used to denote, for example, the rate of ionization or excitation in electron beam pumped plasmas. The rate of ionization is

$$\frac{d[e]}{dt} = \frac{P \left(\frac{W}{\text{cm}^3} \right)}{W(J[\text{or eV}])} \frac{\text{ionizations}}{\text{cm}^3 - \text{s}}$$

where P is the power deposition in the plasma.

In general, for power deposition by high energy electron beams [V(e-beam) > 5-10 kV] the W-value is fairly constant and scales as

$$W_{\text{ionization}} \approx 1.8 - 2 \times \text{ionization potential}$$

$$W_{\text{excitation}} \approx 2x W_{\text{ionization}}$$

Since $W_{\text{ionization}} < W_{\text{excitation}}$ one gets more ionizations in the slowing of a high energy electron beam than excitations. This results from the energy degradation being monotonically from higher energies to lower energies where ionization cross sections are larger. For high energy beams slowing in rare gases,

	Ionization Potential (eV)	$W_{\text{ionization}}$ (eV)	$W_{\text{excitation}}$ (eV)	Ionization / Excitation	“G-value” (Ionizations for 100 eV of deposited energy)
He	24.6	46.8	72.0	1.54	3.53
Ne	20.1	36.5	81.8	2.24	3.96
Ar	15.8	27.3	53.8	1.97	5.52
Kr	14.0	23.6	44.5	1.89	6.48
Xe	12.1	20.9	34.8	1.67	7.66

In a gas discharges, electrons are being accelerated from lower energies to higher energies, and so encounter excitation cross sections before ionization cross sections. The rates of excitation are therefore larger than for ionization. For example, for a gas discharge in xenon,

E/N (Td)	Ionization / Excitation
50	0.014
100	0.08
150	0.16
200	0.22