

Values for the Formation Enthalpy of Vacancies

Illustration

In this module a collection of vacancy data will be built up.

- There might be several values for one and the same quantity, sometimes wildly different. Some colleagues would criticize the "uncritical" inclusion in a table like this.
- Well, discussing incompatible values, always culminating at the conclusion that one's own measurements are superior to the measurements of the others, is one of the joys in the life of a scientist. And of course, there is only one value that can be correct *within the basic assumptions* (e.g. that we have just vacancies, not doing anything in particular except for migrating around a bit). So maybe some measurements were not so good, some evaluations relied on faulty assumptions - or, maybe, the basic premise of single vacancies is wrong.
- Who knows - now. Eventually we will find out what is really going on. *This is the way science works* and students should be aware of this. The [same comment](#) made for the self-diffusion data in **Si** applies.
- In **Si**, for example, the emerging point of view now (July 2001) seems to be that you cannot simply consider just having vacancies, or vacancies and interstitials, but you must consider a complex system of **Si** vacancies, interstitials, oxygen interstitials, **C** substitutional atoms, and all kinds of recombination, pair formation and agglomeration phenomena that interact strongly and couple the point defect concentrations (oxygen precipitation, e.g. produces **Si** interstitial, **C** precipitation eats 'em up). Since the exact situation depends on many parameters, experiments may measure quite different values of just a single parameter - *and those measurements were perfectly correct!*

Element	c_V at T_m $\times 10^{-4}$ Various techniques		H_f [eV] from $\Delta I / I - \Delta a/a$	H_f [eV] from positron annihilation		H_f [eV] from Thermopower	
Ag	1,7 - 5,2 17 - 24	ΔI TE	0,99	1,31 0,89	L M	1,0	TP
Al	3 - 11 20 11 - 22 6	ΔI TE C E	0,65	0,68 0,66	L M		
Au	7,2 14 40 7 5 - 20 3	ΔI TE C Q E QM	0,92	0,89 0,89	L M		
Cd	5 - 6,2 24 40	Δ TE Q		0,52	D		
Cu	2 - 7,6 13 50	Δ TE C	1,04	1,42 1,28	L M		
Co				1,34	A		
Cr				2,0	D		
In				0,56 0,55	L A		
Kr	3						
La						0,98	TD
Li	4						
Mg				0,9	M		

Mo	190 290 - 430	TE C		3,6 3,0 3,0	L M D		
Na	7						
Nb				2,65	D		
Ni				1,78	D		
Pb	1,7 20 - 23	ΔI TE C	0,5	0,65 0,50	L A		
Pd				1,85	D	1,7 1,5	TC TD
Pt	70 - 80 100 26 3	TE C Q QM		1,35 1,32	L D	1,45 1,45	TP TC
Ru						1,75	TD
Si			no values obtained	no values obtained			
Sn	<0,3 6 - 14 13	ΔI TE C		0,54	D		
Ta				2,9 2,8	M D		
Tl				0,46	M		
V				2,07	D		
W	230 210 - 340 1 - 3	TE C QM		4,6 4,1 4,0 3,67	L M D QM		
Zn				0,54	A		

Some remarks

- There are more ways to obtain the formation enthalpy of vacancies from positron annihilation than just measuring the life time. In particular, measurements of
 - Angular correlations between the emitted γ -rays (abbreviated "A")
 - Doppler broadening (abbreviated "D")
 complement the lifetime measurements which also can be done in two modes (*lifetime spectroscopy* "L"; and *mean life time measurements* "M")
 Values given are from the compilation in [Kraftmakhers book](#)..
- Vacancies influence thermal conductivity "TC", thermopower "TP" and thermal diffusivity "TD" of metals, Clever measurements allow to deduce the vacancy formation enthalpy. Values given are from [Kraftmakhers book](#).
- Vacancy concentrations at the melting point can be measured with various techniques. The abbreviations refer to
 - $\Delta I = \Delta I - \Delta a$ method
 - E = stored enthalpy
 - DC = differential calorimetry
 - Q = quenching
 - QM = microscopic observations of quenched samples
 - SH = specific heat
 - TE = thermal expansion.