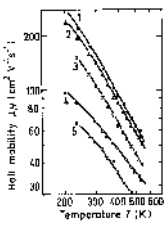
GaP - Gallium Phosphide

Electrical properties

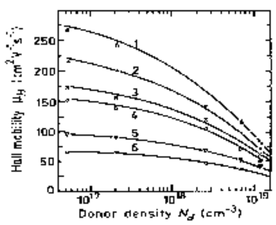
Basic Parameters

Breakdown field	≈1·10^6 V/cm
Mobility electrons	≤250 cm^2 V^{-1}s^{-1}
Mobility holes	≤150 cm^2 V^{-1}s^{-1}
Diffusion coefficient electrons	≤6.5 cm^2/s
Diffusion coefficient holes	≤4 cm^2/s
Electron thermal velocity	2·10^5 m/s
Hole thermal velocity	1.3·10^{5}m/s

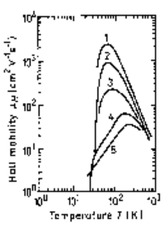
Mobility and Hall Effect



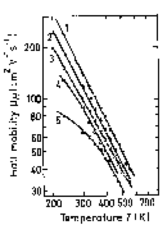
Electron Hall mobility versus temperature for different donor (Sn) densities.
N$_d$ (cm^{-3}): **1**. 5·10^{16}; **2**. 2·10^{17}; **3**. 2.5·10^{18}; **4.** 7.5·10^{18}; **5.** 1.2·10^{19}.
(Kao and Eknoyan [1983]).



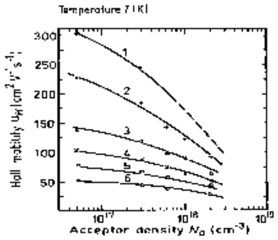
Electron Hall mobility versus donor (Sn) density at different temperature.
T (K): **1**. 203; **2**. 233; **3**. 273; **4**. 300; **5**. 400; **6**. 500.
For T>200 K electron Hall mobility μ_{nH}~T$^{-1.7}$
(Kao and Eknoyan [1983]).



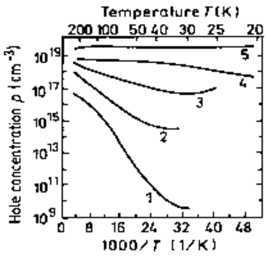
Electron Hall mobility versus temperature for different acceptor (Zn) densities.
N$_a$ (cm^{-3}): **1**. 6.7·10^{16}; **2**. 1.9·10^{17}; **3**. 6.7·10^{17}; **4**. 3.8·10^{18}; **5**. 1.2·10^{19}.
(Casey et al. [1969]).



Hole Hall mobility versus temperature for different acceptor (Mg) densities.
N$_a$ (cm^{-3}): **1**. 5·10^{16}; **2**. 3·10^{17}; **3**. 6·10^{17}; **4**. 1·10^{18}; **5**. 2·10^{18}.
(Kao and Eknoyan [1983]).

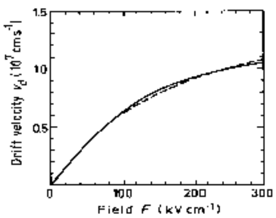


Hole Hall mobility versus acceptor (Mg) density at different temperature.
T (K): **1**. 203; **2**. 233; **3**. 300; **4**. 350; **5**. 400; **6**. 500.
For T>200 K hole Hall mobility μ_{pH}~T$^{-2.3}$
(Kao and Eknoyan [1983]).



Hole concentration versus temperature for different acceptor (Zn) densities.
N_a (cm^{-3}): **1**. $6.7\cdot 10^{16}$; **2**. $6.7\cdot 10^{17}$; **3**. $3.8\cdot 10^{18}$; **4**. $1.2\cdot 10^{19}$; **5**. $2.1\cdot 10^{19}$.
(Casey et al. [1969]).

Transport Properties in High Electric Fields

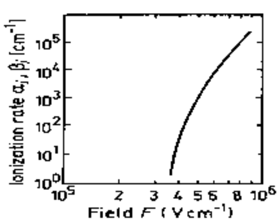


Field dependences of the electron drift velocity 300 K.
Solid line shows the result of the calculation.
Dashed line shows the experimental results
(Arora et al. [1987]).

Saturation electron drift velocity

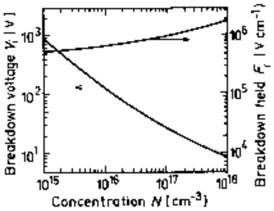
$v_s = 1.25\cdot 10^7$ cm/s (300 K)
(Johnson and Eknoyan [1985])

Impact Ionization



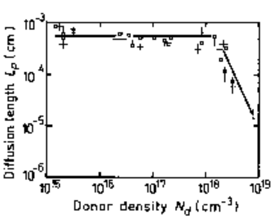
The dependence of ionization rates for electrons α_i and holes β_i versus electric field, 300 K.
$\alpha_i = \beta_i$
(Sze [1969]).

At 300 K for $5\cdot 10^5$ V/cm < F < $1.3\cdot 10^6$ V/cm
$\alpha_i = \beta_i = \alpha_o\cdot\exp(\delta - (\delta^2 + (F_o/F)^2)^{1/2}$,
where $\alpha_o = 0.39\cdot 10^6$ cm^{-1}, δ=19.1, F_o=$7.51\cdot 10^6$ V cm^{-1}
(Kyuregyan and Yurkov [1989]).

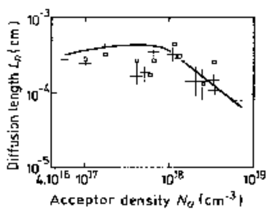


Breakdown voltage and breakdown field versus doping density for an abrupt *p-n* junction, 300 K
(Sze and Fibbons [1966]).

Recombination Parameters



Hole diffusion length L_p in *n*-type GaP (undoped or doped with S) versus donor density, 300 K
(Young and Wight [1974]).



Electron diffusion length L_n in *p*-type GaP versus acceptor (Zn) density, 300 K
(Young and Wight [1974]).

The longest lifetime of holes (undoped GaP) $\tau_p \sim 1\cdot 10^{-6}$ s

Diffusion length $L_p = (D_p \cdot \tau_p)^{1/2}$	$L_p \sim 20$ µm.
The longest lifetime of electrons	$\tau_n \sim 1 \cdot 10^{-7}$ s
Diffusion length $L_n = (D_n \cdot \tau_n)^{1/2}$	$L_n \sim 7$ µm

Surface recombination
(Gershenzon and Mikulyak [1966])

20 K	$(0.1 \div 3.4) \cdot 10^2$ cm/s
77 K	$(1.1 \div 90) \cdot 10^4$ cm/s
300 K	$(0.4 \div 2) \cdot 10^6$ cm/s

Radiative recombination

Band to band radiative recombination coefficient	$- 10^{-13}$ cm^3/s

Impurity recombination at 300 K
(Yunovich [1972], Bergh and Dean[1976])

Zn-O complex (red LED, $h\nu \approx 1.8$ eV, $\lambda \approx 0.7$ µm)

Radiative exciton lifetime	$\sim 10^{-7}$ s^{-1}
Oscillator force for exciton recombination	0.07
Non - radiative exciton lifetime: $\tau_{xn} = 1/B \cdot p$	$B \approx 10^{-10} \div\!- 10^{-11}$ cm^3/s
Non - radiative single electron lifetime: $\tau_{cn} = 1/C \cdot p^2$	$C \approx 10^{-30}$ cm^6/s

N - isoelectron impurity (green LED, $h\nu \sim 2.22$ eV, $\lambda \sim 0.56$ µm)

Radiative exciton lifetime	$- 3 \cdot 10^{-8}$ s
Oscillator force for exciton recombination	0.09
Bond energy of exciton in GaP doped with N:	
free exciton	0.021 eV
N N bound exciton	0.143 eV

Auger recombination coefficient	$- 10^{-30}$ cm^6/s