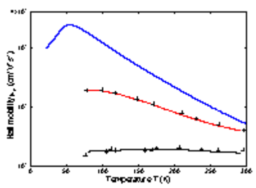
InP - Indium Phosphide

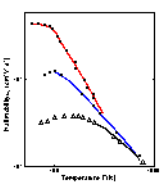
Electrical properties

Basic Parameters

Breakdown field	$\approx 5\cdot 10^5$ V cm^{-1}
Mobility electrons	≤ 5400 cm^{2}V^{-1}s^{-1}
Mobility holes	≤ 200 cm^2 V^{-1}s^{-1}
Diffusion coefficient electrons	≤ 130 cm^2 s^{-1}
Diffusion coefficient holes	≤ 5 cm^2 s^{-1}
Electron thermal velocity	$3.9\cdot 10^5$ m s^{-1}
Hole thermal velocity	$1.7\cdot 10^5$ m s^{-1}



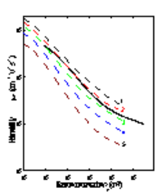
Electron Hall mobility versus temperature for different doping levels.
Bottom curve - $n_o=N_d-N_a=8\cdot 10^{17}$ cm^{-3};
Middle curve - $n_o=2\cdot 10^{15}$ cm^{-3};
Top curve - $n_o=3\cdot 10^{13}$ cm^{-3}.
(Razeghi et al. [1988]) and *(Walukiewicz et al [1980])*.



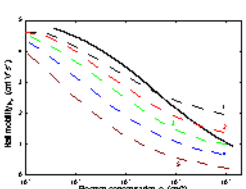
Electron Hall mobility versus temperature (high temperatures):
Bottom curve - $n_o=N_d-N_a\sim 3\cdot 10^{17}$ cm^{-3};
Middle curve - $n_o\sim 1.5\cdot 10^{16}$ cm^{-3};
Top curve - $n_o\sim 3\cdot 10^{15}$ cm^{-3}.
(Galavanov and Siukaev[1970]).

For weakly doped *n*-InP at temperatures close to 300 K electron drift mobility:

$\mu_n = (4.2\div 5.4)\cdot 10^3\cdot(300/T)$ (cm^{2}V^{-1} s^{-1})



Hall mobility versus electron concentration for different compensation ratios.
$\theta = N_a/N_d$, 77 K.
Dashed curves are theoretical calculations: **1**. $\theta = 0$; **2**. $\theta = 0.2$; **3**. $\theta = 0.4$; **4**. $\theta = 0.6$; **5**. $\theta = 0.8$;
(Walukiewicz et al. [1980]).
Solid line is mean observed values *(Anderson et al. [1985])*.



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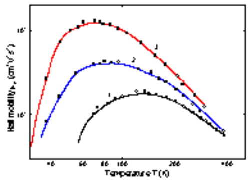
Approximate formula for electron Hall mobility

$\mu=\mu_{OH}/[1+(N_d/10^7)^{1/2}]$,
where $\mu_{OH}=5000$ cm^{2}V^{-1} s^{-1},
N_d- in cm^{-3} *(Hilsum [1974])*

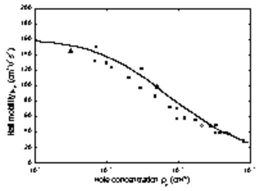
At 300 K, the electron Hall factor $\mathbf{r_n \approx 1}$ in *n*-InP.
for $N_d > 10^{15}$ cm^{-3}.



Hole Hall mobility versus temperature for different doping (Zn) levels.
Hole concentration at 300 K: **1**. $1.75\cdot10^{18}$ cm^{-3}; **2**. $3.6\cdot10^{17}$ cm^{-3}; **3**. $4.4\cdot10^{16}$ cm^{-3}.
$\theta=N_a/N_d\sim0.1$.
(Kohanyuk et al. [1988]).

For weakly doped *p*-InP at temperature close to 300 K the Hall mobility

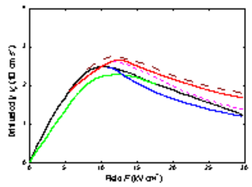
$\mu_{pH}\sim150\cdot(300/T)^{2.2}$ (cm^2V^{-1} s^{-1}).



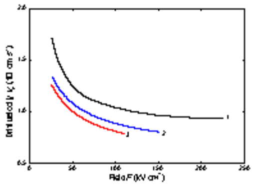
Hole Hall mobility versus hole density, 300 K (Wiley [1975]).
The approximate formula for hole Hall mobility:
$\mu_p=\mu_{po}/[1 + (N_a/2\cdot10^{17})^{1/2}]$, where $\mu_{po}\sim150$ cm^2V^{-1} s^{-1}, N_a- in cm^{-3}

At 300 K, the hole factor in pure *p*-InP: $\mathbf{r_p\sim1}$

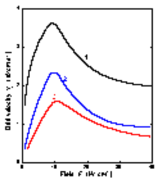
Transport Properties in High Electric Fields



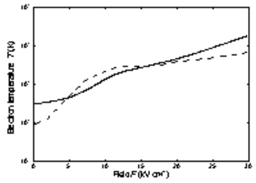
Field dependences of the electron drift velocity in InP, 300 K.
Solid curve are theoretical calculation.
Dashed and dotted curve are measured data.
(Maloney and Frey [1977]) and *(Gonzalez Sanchez et al. [1992])*.



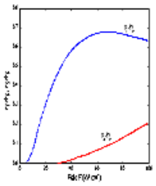
The field dependences of the electron drift velocity for high electric fields.
T(K): **1**. 95; **2**. 300; **3**. 400.
(Windhorn et al. [1983]).



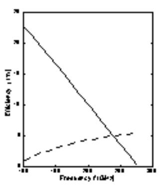
Field dependences of the electron drift velocity at different temperatures.
Curve 1 -77 K *(Gonzalez Sanchez et al. [1992])*.
Curve 2 - 300 K, Curve 3 - 500 K *(Fawcett and Hill [1975])*.



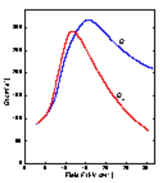
Electron temperature versus electric field for 77 K and 300 K.
(Maloney and Frey [1977])



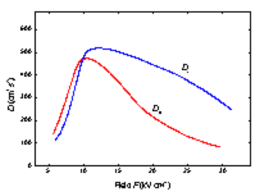
Fraction of electrons in L and X valleys n_L/n_o and n_X/n_o as a function of electric field, 300 K.
(Borodovskii and Osadchii [1987]).



Frequency dependence of the efficiency η at first (solid line) and at the second (dashed line) harmonic in LSA mode.
Monte Carlo simulation.
$F = F_o + F_1 \cdot \sin(2\pi \cdot ft) + F_2 \cdot [\sin(4\pi \cdot ft)+3\pi/2]$,
$F_o=F_1=35$ kV cm^{-1},
$F_2=10.5$ kV cm^{-1}
(Borodovskii and Osadchii [1987]).



Longitudinal (D || F) and transverse (D ⊥ F) electron diffusion coefficients at 300 K.
Ensemble Monte Carlo simulation.
(Aishima and Fukushima [1983]).



Longitudinal (D || F) and transverse (D ⊥ F) electron diffusion coefficients at 77K.
Ensemble Monte Carlo simulation.
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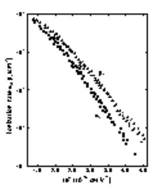
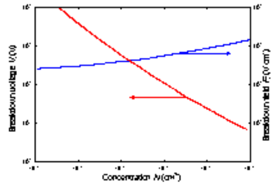
Impact Ionization



The dependence of ionization rates for electrons α_i and holes β_i versus 1/F, 300 K.
(Cook et al. [1982]).



Breakdown voltage and breakdown field versus doping density for an abrupt *p-n* junction, 300 K
(Kyuregyan and Yurkov [1989]).

Recombination Parameters

Pure *n*-type material (n_o ~ 10^{-14}cm^{-3})

The longest lifetime of holes	τ_p ~ $3\cdot10^{-6}$ s
Diffusion length $L_p = (D_p\cdot\tau_p)^{1/2}$	L_p ~ 40 µm.

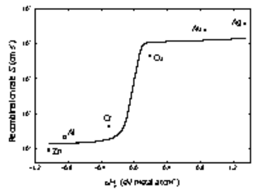
Pure *p*-type material(p_o ~ 10^{15}cm^{-3})

(a)Low injection level

The longest lifetime of electrons	τ_n ~ $2\cdot10^{-9}$ s
Diffusion length $L_n = (D_n\cdot\tau_n)^{1/2}$	L_n ~ 8 µm

(b) High injection level (filled traps)

The longest lifetime of electrons	τ ~ 10^{-8} s
Diffusion length L_n	L_n ~ 25 µm



Surface recombination velocity versus the heat of reaction per atom of each metal phosphide ΔH_R
(Rosenwaks et al. [1990]).

If the surface Fermi level E_{FS} is pinned close to midgap (E_{FS}~$E_g/2$) the surface recombination velocity increases from ~$5\cdot10^{-3}$cm/s for doping level n_o~$3\cdot10^{15}$ cm^{-3} to ~10^6 cm/s for doping level n_o ~ $3\cdot10^{18}$cm^{-3} (Bothra et al. [1991]).

Radiative recombination coefficient (300 K)	$1.2\cdot10^{-10}$ cm^3/s
Auger coefficient (300 K)	~$9\cdot10^{-31}$ cm^6/s