InSb - Indium Antimonide

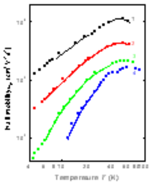
Electrical properties

Basic Parameters
Mobility and Hall Effect
Transport Properties in High Electric Fields
Impact Ionization
Recombination Parameters

Basic Parameters

Breakdown field	$\approx 10^3$ V cm^{-1}
Mobility Electrons	$\leq 7.7\cdot 10^4$ cm^{2}V^{-1}s^{-1}
Mobility Holes	≤ 850 cm^{2}V^{-1}s^{-1}
Diffusion coefficient Electrons	$\leq 2\cdot 10^3$ cm^{2}s^{-1}
Diffusion coefficient Holes	≤ 22 cm^{2}s^{-1}
Electron thermal velocity	$9.8\cdot 10^5$ m s^{-1}
Hole thermal velocity	$1.8\cdot 10^5$ m s^{-1}

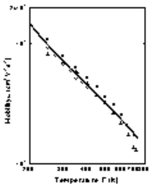
Mobility and Hall Effect



Electron Hall mobility versus temperature for different doping levels and different compensation ratios

Curve	N_d (cm^{-3})	$\theta = N_a/N_d$
1.	$3.85\cdot 10^{14}$	0.5
2.	$8.5\cdot 10^{14}$	0.88
3.	$9.5\cdot 10^{14}$	0.98
4.	$1.35\cdot 10^{15}$	0.99

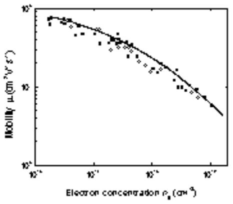
(Yaremenko et al. [1973]).



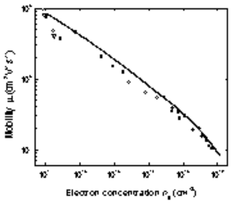
Electron mobility versus temperature (high temperatures).
Solid line is theoretical calculation for electron-drift mobility.
Experimental data are Hall mobilities.
(Rode [1971]).

For pure *n*-InSb at T ≥ 200K:

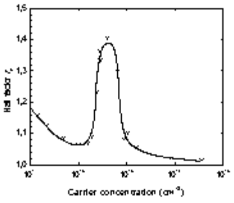
$\mu_{nH} \approx 7.7\cdot 10^4 (T/300)^{-1.66}$ (cm^2 V^{-1} s^{-1}).



Electron mobility versus electron concentration. T = 300 K
(Litwin-Staszewska et al. [1981]).



Electron mobility versus electron concentration. T = 77 K
(Litwin-Staszewska et al. [1981]).



The electron Hall factor versus carrier concentration. T = 77 K
(Baranskii and Gorodnichii [1969]).

Maximal electron mobility for pure *n*-InSb

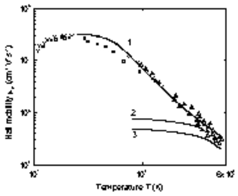
77 K	$1.2\cdot10^{6}$ cm^{2}V^{-1}s^{-1}
300 K	$7.7\cdot10^{4}$ cm^{2}V^{-1}s^{-1}

Maximal electron mobility for InSb grown on GaAs substrate

77K	$1.5\cdot10^{5}$ cm^{2}V^{-1}s^{-1} ($n_o = 2.2\cdot10^{15}$ cm^{-3})
300 K	$7.0\cdot10^{4}$ cm^{2}V^{-1}s^{-1} ($n_o = 2.0\cdot10^{16}$ cm^{-3})

Maximal electron mobility for InSb grown on InP substrate

77 K	$1.1\cdot10^{5}$ cm^{2}V^{-1}s^{-1}
300 K	$7.0\cdot10^{4}$ cm^{2}V^{-1}s^{-1}



Hole Hall mobility versus temperature for different hole concentrations.

p_o (cm^{-3}):

1. $8\cdot10^{14}$;

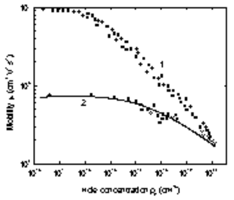
2. $3.15\cdot10^{18}$;

3. $2.5\cdot10^{19}$;

(Zimpel et al. [1989]) and *(Filipchenko and Bolshakov [1976])*.

For pure *p*-InSb at T > 60K:

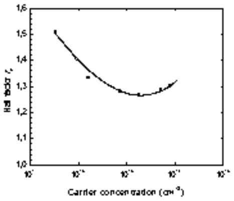
$\mu_{pH} \approx 850(T/300)^{-1.8}$ (cm^{2}V^{-1}s^{-1})



Hall mobility versus hole concentrations:

1. 77 K *(Filipchenko and Bolshakov [1976])*;

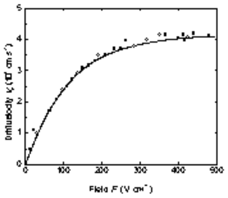
2. 290K *(Wiley [1975]).*



The hole Hall factor versus carrier concentration, 77 K

(Baranskii and Gorodnichii [1969]).

Transport Properties in High Electric Fields

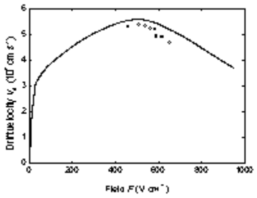


Field dependence of the electron drift velocity, 77 K.

Solid lines is the Monte Carlo calculation.

Points are experimental data.

(Asauskas et al. [1980]).

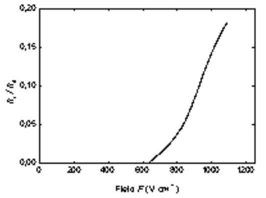


Field dependence of the electron drift velocity, 77 K.

Solid lines is the Monte Carlo calculation.

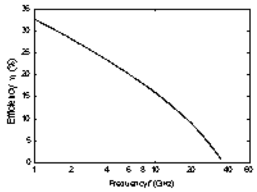
Points are experimental data.

(Neukermans and Kino [1973]).



Fraction of electrons in the L-valley as a function of electric field F, 77K

(Asauskas et al. [1980]).

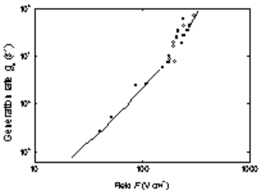


Frequency dependence of the efficiency in LSA mode
$F_o = F + F_1 \sin(2\pi \cdot ft)$:

$F_o = 2.5$ kV cm^{-1}

(Prokhorov et al. [1977]).

Impact Ionization

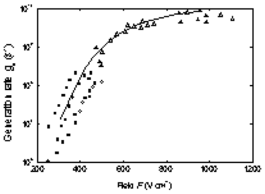


The dependence of generation rate for electrons g_n versus electric field F, 300 K
(Vorob'ev et al. [1983]).

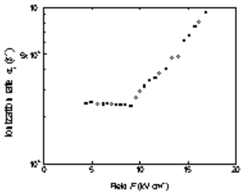
For 300 K, for 30 V/cm < F < 300 V/cm:

$$g_n(F) = 126 \cdot F^2 \exp(F/160)\ (s^{-1}),$$

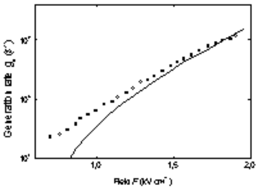
where F is in V cm^{-1}.



The dependence of generation rate for electrons g_n versus electric field F, 77 K
(Krotkus and Dobrovolskis [1988]) and *(Vorob'ev et al. [1988])*.



The dependence of ionization rates for electrons α_i versus the electric field F, T=78 K
(Gavrushko et al. [1978]).

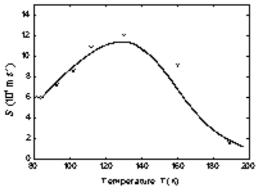


The dependence of generation rate for holes g_p versus the electric field F, T =77K
(Adomaitis et al. [1985]).

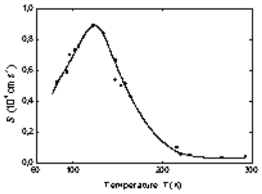
Recombination Parameters

For pure InSb at T≥250K lifetime of carrier (electrons and holes) is determined by Auger recombination:
$\tau_n = \tau_p \approx 1/C\, n_i^2$,
where $C \approx 5 \cdot 10^{-26}$ cm^{-6} s^{-1} is the Auger coefficient.
n_i is the intrinsic carrier concentration.

For T = 300 K	$\tau_n = \tau_p \approx 5 \cdot 10^{-8}$ s
For T = 77K	
n-type: the lifetime of holes	$\tau_p \sim 10^{-6}$ s
p-type: the lifetime of electrons	$\tau_n \sim 10^{-10}$ s



Temperature dependence of surface recombination velocity for *p*-InSb.
(Euthymiou et al. [1981]).



Temperature dependence of surface recombination velocity for *n*-InSb.
(Skountzous and Euthymiou [1976]).

Radiative recombination coefficient	~$5\cdot10^{-11}$ cm^{3}s^{-1}
Auger coefficient	~$5\cdot10^{-26}$ cm^{6}s^{-1}