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# List of Acronyms and Abbreviations

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## Numerical Methods and Computer Software

FEM	finite element method
TLM	transmission-line matrix
FDTD	finite-difference time-domain
FDTLM	frequency-domain transmission-line matrix
MoM	Method of moments
HFSS	High Frequency Structure Simulator
CST	Microwave CST Studio
2-D	two dimensional
3-D	three dimensional
SCN	symmetrical condensed node
PML	perfectly matched layer
PDCM	photodistributed current model
BTE	Boltzmann transport equation
MC	Monte Carlo
DD	drift-diffusion
EB	energy balance
HD	hydrodynamic
LHS	left hand side
RHS	right hand side
SG	Scharfetter and Gummel

## Electromagnetics

EM	electromagnetic
CW	continuous wave
RF	radio frequency
MMW	millimeter-wave
LO	local oscillator
DC	zero frequency
RC	resistance-capacitance
CPW	coplanar waveguide
CPS	coplanar stripline
RPW	reverse-propagating wave
FPW	forward-propagating wave
E	electric
H	magnetic
PEC	perfect electric conductor
PMC	perfect magnetic conductor
TE	transverse electric
TM	transverse magnetic



## **Optoelectronics**

EO	electrooptic
OCS	optical communication system
PLO	photonic local oscillator
OFP	optical field profile

## **Photodetectors**

VPD	vertically illuminated photodetector
WGPD	waveguide photodetector
TWPD	traveling-wave photodetector
VMDPD	velocity-matched distributed photodetector
PD	photodiode
UTC	uni-traveling-carrier
MSM	metal-semiconductor-metal
FWHM	full-width half-maximum

## **Semiconductors**

UD	unintentionally doped
SI	semi-insulating
LTG	low-temperature-grown
EH	electron-hole
SRH	Shockley-Read-Hall
GR	generation-recombination
QW	quantum well
MBE	molecular-beam epitaxy
MSM	Metal-Semiconductor-Metal device type
GaAs	Gallium Arsenide
HDCTM	Hydrodynamic Carrier Transport Model
DDCTM	Drift-Diffusion Carrier Transport Model.

# List of Symbols

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$f$	frequency	[GHz]
$\omega$	radial frequency	[rad/s]
$c$	velocity of light in free space	[m/s]
$\vec{E}$	electric field vector	[V/m]
$\vec{H}$	magnetic field vector	[A/m]
$\vec{D}$	electric displacement vector	[As/m <sup>2</sup> ]
$\vec{B}$	magnetic induction vector	[Vs/m <sup>2</sup> ]
$Z$	impedance	[ $\Omega$ ]
$R_L$	Load resistance	[ $\Omega$ ]
$\epsilon_0$	dielectric permittivity constant	[A s/(V m)]
$\mu_0$	magnetic permeability constant	
$\epsilon_r$	relative dielectric permittivity	
$\mu_r$	relative magnetic permeability	
$\vec{A}$	vector field potential	
$\vec{j}$	current density vector	[A/m <sup>2</sup> ]
$I_{ph}$	Photomixer photocurrent	[A]
$I_{NIR}$	Near Infrared Radiation Intensity	
$\mathcal{R}$	Responsivity	[A/W]
$Z_0$	characteristic impedance	[ $\Omega$ ]
$R_A$	Antenna impedance	[ $\Omega$ ]
$Y_0$	characteristic admittance	[S]
$h$	Planck's constant	[Js]
$\hbar$	Planck's constant	[Js]
$k_B$	Boltzmann's constant	[J/K]
$D_e$	Diffusion's constant	[cm <sup>2</sup> /s]
$\rho$	volume charge density	[cm <sup>-3</sup> ]
$n$	electron concentration	[cm <sup>-3</sup> ]
$p$	hole concentration	[cm <sup>-3</sup> ]
$N_A$	Acceptor concentration	[cm <sup>-3</sup> ]
$N_D$	Donor concentration	[cm <sup>-3</sup> ]
$n_1$	Concentration of trap states for electrons	[cm <sup>-3</sup> ]
$p_1$	Concentration of trap states for holes	[cm <sup>-3</sup> ]
$n_i$	Intrinsic carrier concentration	[cm <sup>-3</sup> ]
$\varphi$	electrostatic potential	[V]
$\vec{x}$	spatial position	[cm]
$\vec{k}$	wave vector	[1/cm]
$\vec{u}_v$	carrier group velocity	[cm/s]
$f_v$	non-equilibrium probability distribution	
$f_{v_0}$	equilibrium probability distribution	
$F_{ve}$	external force	[CV/cm]
$R_v$	carrier recombination rate	[cm <sup>-3</sup> s <sup>-1</sup> ]
$G_v$	carrier generation rate	[cm <sup>-3</sup> s <sup>-1</sup> ]

$\vec{v}_v$	carrier drift velocity	[cm/s]
$\vec{v}_{tv}$	carrier thermionic recombination velocity	[cm/s]
$\vec{p}_v$	carrier momentum	[kg-cm/s]
$W_v$	carrier energy	[J]
$W_{v_0}$	equilibrium energy	[J]
$\vec{S}_v$	carrier energy flux	[Jcm <sup>-2</sup> s <sup>-1</sup> ]
$T_v$	carrier temperature	[K]
$T_L$	crystal lattice temperature	[L]
$f_v^{hf}$	Coefficients for heat flux	
$f_v^{td}$	Coefficients for thermal diffusion	
$r_v$	Coefficients for energy flux	
$m_v^*$	carrier constant effective mass	[kg]
$\tau_{pv}$	momentum relaxation time	[s]
$\tau_{\omega v}$	energy relaxation time	[s]
$\tau_v$	carrier lifetime	[s]
$\tau_{el}$	Electrode time	[s]
$\tau_{tr}$	Transit time	[s]
$\tau_A$	Transit time through the absorption layer	[s]
$\tau_C$	Transit time through the collection layer	[s]
$\tau_{RC}$	RC time	[s]
$\tau_{rec}$	Recombination time	[s]
$W_A$	Absorption layer thickness	[cm]
$v_{th}$	Thermionic emission velocity ( $2.5 \times 10^7$ cm/s)	[cm/s]
$v_{OS}$	Velocity overshoot of the electrons	[cm/s]
$\vec{J}_v$	carrier current density	[A/cm <sup>2</sup> ]
$\mu_v$	carrier mobility	[cm <sup>2</sup> /(Vs)]
$E_g$	energy gap	[eV]
$E_{trap}$	Difference between the defect and intrinsic level	[eV]
$\chi$	electron affinity	[eV]
$\eta$	quantum efficiency	
$\eta_{int}$	internal quantum efficiency	
$\mathcal{R}$	responsivity	[A/W]
$\vec{v}_{sv}$	carrier saturation velocity	[m/s]
$\Gamma_{opt}$	optical confinement factor	
$M$	Modulation index	
$\ell_{OE}$	Optical and electrical losses	
$\alpha_{opt}$	optical power absorption coefficient	[m <sup>-1</sup> ]
$\alpha_{RF}$	attenuation coefficient	[m <sup>-1</sup> ]
$P_{opt}$	Optical power	[W]
$P_{RF}$	Microwave power	[W]
$P_{THZ}$	Terahertz power	[W]
$P_{inj}$	Input optical power	[W]
$\epsilon_{eff}$	effective permittivity of RF waveguide	
$Z_0$	characteristic impedance	[ $\Omega$ ]
$c$	light speed in free space	[m/s]

$B_{vm}$	velocity mismatch bandwidth [Hz]	
$I_{vm}$	frequency response due to velocity mismatch	[dB]
$I_{tr}$	transit frequency response	[dB]
$I_f$	total frequency response	[dB]
$\theta$	thermal impedance	[°C mm/W]
$\sigma_t$	thermal conductivity	[W/(°Cmm)]
$T_{opt}$	duration of the optical pulse	[s]
$R_{opt}$	optical reflection coefficient	

Subscript  $\nu$  stands for “ $n$ ” and “ $p$ ” denoting the respective quantity for electrons or holes.