Thermionic graphene/silicon Schottky infrared photodetectors

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S1. LIST OF SYMBOLS AND ACRONYMS

$\alpha_{l,\mathrm{SLG}}$	Graphene lattice constant
$c_{e,\mathrm{SLG}}$	Graphene electronic heat capacity
C_j	Graphene/Semiconductor junction capacitance
$c_{l,\mathrm{SLG}}$	Graphene lattice heat capacity
$C_{q,\mathrm{SLG}}$	Graphene quantum capacitance
CMOS	Complementary metal-oxide-semiconductor
CNP	Charge neutrality point
D^*	Specific detectivity
d_{Au}	Au backmirror thickness
$d_{n,\mathrm{Si}}$	n-doped Si layer thickness
d_{Si}	Undoped Si layer thickness
$d_{\mathrm{SiO_2}}$	Silicon dioxide layer thickness
D_{SLG}	Deformation potential for disorder – assisted supercollisions
d_{SLG}	Graphene layer thickness
$E_{C,\mathrm{Si}}$	Silicon conduction band energy level
$E_{F,\mathrm{Si}}$	Silicon Fermi level
$E_{F,\mathrm{SLG}}$	Graphene Fermi level
$E^{'}_{F,\mathrm{SLG}}$	Graphene Fermi level before contact with Silicon
$E_{F0,\mathrm{SLG}}$	Graphene Fermi level upon contact with Silicon at zero bias
$E_{g,\mathrm{Si}}$	Silicon bandgap
$e-h$	Electron hole pair
EPC	Electron phonon coupling
$e-ph$	Electron phonon
$e\phi_{\mathrm{Si}}$	Energy difference between Silicon conduction band and fermi level
F	Inverse surface coverage ratio
FWHM	Full-width at half-maximum
f_{FD}	Fermi - Dirac distribution
f_{opt}	Optics limited operation frequency

f_{RC}	Electronics limited operation frequency
f_{tr}	Carriers' transition limited frequency
i_d	Dark current
i_j	Johnson (thermal) noise current
i_n	Total noise current
I_{ph}	Photocurrent
i_s	Shot noise current
IPE	Internal photoemission
IR	Infrared
J_d	Saturation current density at dark
J_{el}	Photocurrent density
$J_{e-\mathrm{ph}}$	Total electron-to-phonon thermal current density
J_{op}	Electron-to-optical phonon thermal current density
J_R	Total reverse current density under illumination
J_{SC}	Electron-to-phonon thermal current density due to supercollisions
J_{th}	Thermal current density due to thermionic emission of carriers
$k_{F,\mathrm{SLG}}$	Graphene Fermi wavevector
L	Optical cavity length
LDR	Linear dynamical range
l	Mean free path for supercollision scattering
MWIR	Mid wave infrared
$N(x)$	Bose – Einstein distribution
n^*_{SLG}	Free carrier concentration associated with graphene doping
$n_{0,\mathrm{SLG}}$	Initial (before contact) graphene carrier concentration
n_{Au}	Au layer refractive index
$N_{C,\mathrm{Si}}$	Effective density of states in the conduction band of silicon
$N_{d,\mathrm{Si}}$	Silicon donor concentration
$n_{e,\mathrm{SLG}}$	Graphene electron concentration
$n_{h,\mathrm{SLG}}$	Graphene hole concentration

$n_{\mathrm{min,SLG}}$	Graphene minimum carrier density
n_{Si}	Silicon layer refractive index
$n_{\mathrm{SiO_2}}$	Silicon dioxide layer refractive index
$N_{V,\mathrm{Si}}$	Effective density of states in the valence band of silicon
$N_{\alpha,\mathrm{Si}}$	Silicon acceptor concentration
NEP	Noise equivalent power
nSi	n – doped Silicon
nSLG	n – doped single layer graphene
P_{in}	Input power density
pSi	p – doped Silicon
pSLG	p – doped single layer graphene
PD	Photodetector
PTh	Photothermionic
PV	Photovoltaic
Q	Bragg cavity quality factor
R	External responsivity
R_C	Contact resistance
R_{CW}	Quasi-cw illumination external responsivity
R_{el}	Sum of series and contact resistance
R_{eq}	Equivalent resistance at reverse bias in dark
R_{lin}	Linear regime external responsivity
R_{peak}	Peak external responsivity
R_s	Series total resistance
R_{Si}	Silicon layer resistance
R_{SLG}	Single layer graphene resistance
RT	Room temperature
S	Single layer graphene geometrical cross section
S_0	Diffraction limited area
s_{SLG}	Sound velocity on single layer graphene

SBH	Schottky barrier height
SC	Semiconductor
SLG	Single layer graphene
SNR	Signal to noise ratio
$T_{e,\mathrm{Si}}$	Electronic temperature in Silicon
$T_{e,\mathrm{SLG}}$	Electronic temperature in single layer graphene
$T_{l,\mathrm{SLG}}$	Lattice temperature in single layer graphene
V_0	Built in potential in depletion region
$v_{F,\mathrm{SLG}}$	Graphene Fermi velocity
V_R	Reverse bias voltage
$V_R^{'}$	Reverse bias voltage drop in silicon depletion region
V_R^{BD}	Reverse bias breakdown potential
$v_{\mathrm{sat},Si}$	Carrier saturation velocity in silicon
$\alpha_{\mathrm{inter,SLG}}$	Single layer graphene interband absorption
α_{SLG}	Single layer graphene absorption
γ_a	Total absorption rate in Bragg cavity
γ_d	Total decay rate in Bragg cavity
$\Gamma_{\mathrm{SLG\text{-}Si}}$	Cooling rate from single layer graphene to Silicon
γ_{SC}	Prefactor for calculation of supercollision scattering
$\delta_{n,\mathrm{SLG}}$	Graphene non-equilibrium carrier density
$\Delta E_{F,\mathrm{SLG}}$	Induced graphene Fermi level shift due to reverse bias
$\Delta Q_{D,\mathrm{Si}}$	Induced change in depletion region charge due to reverse bias
ΔQ_{SLG}	Induced change in single layer graphene charge due to reverse bias
$\delta\Phi_B$	Induced change in Schottky barrier height due to reverse bias
ϵ_{Si}	Silicon dielectric permittivity
ϵ_{SLG}	Single layer graphene dielectric function
$\epsilon_{\infty,\mathrm{SLG}}$	High frequency limit of the graphene dielectric permittivity
$\mu_{c,\mathrm{SLG}}$	Graphene conduction band non-equilibrium chemical potential
$\mu_{e,\mathrm{Si}}$	Electron mobility in Silicon

$\mu_{q,\mathrm{SLG}}$	Carrier mobility in single layer graphene
$\mu_{\mathrm{SLG}}^{'}$	Graphene chemical potential before contact with silicon
μ_{SLG}	Graphene equilibrium chemical potential
$\mu_{v,\mathrm{SLG}}$	Graphene valence band non-equilibrium chemical potential
$\mu_{0,\mathrm{SLG}}$	Graphene chemical potential upon contact with silicon at zero bias
$\nu(\epsilon)$	Graphene density of electronic states
ρ_{SLG}	Graphene mass density
$\sigma_{\mathrm{DC,SLG}}$	Graphene DC conductivity
$\sigma_{\mathrm{inter}}^{\mathrm{opt}}$	Graphene interband optical conductivity
$\sigma_{\mathrm{intra}}^{\mathrm{opt}}$	Graphene intraband optical conductivity
$\sigma_{\mathrm{SLG}}^{\mathrm{opt}}$	Graphene total optical conductivity
τ	Total temporal response limit
τ_{e-e}	Time scale for relaxation in a Fermi – Dirac distribution in graphene
$\tau_{e-\mathrm{ph}}$	Time scale for electron – phonon scattering in graphene
τ_{inj}	Time scale for carrier injection from graphene to semiconductor
τ_{opt}	Free electron relaxation time related to charge carrier's mobility in graphene
τ_{ph}	Photon lifetime inside the optical cavity
τ_{pulse}	Pulse duration of illumination source
τ_{RC}	Charge/discharge RC time constant of the diode/circuit combination
τ_{tr}	Transit time of charge carriers across the depletion zone
Φ_B	Schottky barrier height
Φ_{B0}	Schottky barrier height upon contact at zero bias
Φ_{B0}^{min}	Lower limit of Schottky barrier height
Φ_B^{CNP}	Schottky barrier height in respect to graphene charge neutrality point
Φ_{Si}	Silicon workfunction
$\Phi_{\mathrm{SLG}}^{'}$	Graphene workfunction before contact with silicon
Φ_{SLG}	Graphene workfunction upon contact with silicon
χ_d	Depletion region width
χ_{Si}	Silicon electron affinity

χ_{SLG}	Single layer graphene electron affinity
$\Omega_{i,\mathrm{SLG}}$	Graphene optical phonon energy

TABLE S1: Summary of symbols and acronyms used throughout this work.