

Anexos

Anexo I. Medición de las características de salida

Una vez que se ha montado el sistema de medición con la configuración recomendada de la sección 2.2.3, se utiliza la siguiente secuencia de programación en Test Script Builder para la obtención de las características de salida para diferentes valores de voltaje de puerta (V_g):

```
--Se reinicia los instrumentos, la conexión TSP-Link, y se limpian los
buffers.
tsplink.initialize()
reset()
node[2].reset()
state = tsplink.state
if state ~= "online" then
print("Error:\n-Revisar que los dispositivos tienen diferente numero de
nodo")
print("-Revisar que todos los dispositivos estan conectados
correctamente\n")
return
end
--Se programa el número de puntos de medición
num = 51
--##### Configuración (Drenador) SMU 1 #####
smu.source.func = smu.FUNC_DC_VOLTAGE
smu.source.ilimit.level = 300e-3
smu.source.autorange = smu.ON
smu.measure.func = smu.FUNC_DC_CURRENT
smu.measure.autorange = smu.ON
smu.measure.terminals = smu.TERMINALS_FRONT
--Se programa el rango del barrido del voltaje Vds
smu.source.sweeplinear('MOSFET', -1, 1, num, 0.001)
--##### configuración (Gate) SMU 2 #####
node[2].smu.source.func = node[2].smu.FUNC_DC_VOLTAGE
node[2].smu.source.autorange = node[2].smu.ON
node[2].smu.source.ilimit.level = 100e-3
node[2].smu.measure.func = node[2].smu.FUNC_DC_CURRENT
```

```

node[2].smu.measure.autorange = node[2].smu.ON
node[2].smu.measure.terminals = node[2].smu.TERMINALS_FRONT
node[2].smu.source.output = node[2].smu.ON
readings = {}
sourcevalues = {}
iteration = 0
steppoints = 4
--Se programan los valores de Vg (En este caso 0.2V, 0.3V, 0.4V y 0.5V)
for i = 2, 5 do
node[2].smu.source.level = i/10
delay(0.01)
trigger.model.initiate()
waitcomplete()
for j = 1, num do
readings[j+iteration*num] = defbuffer1[j]
sourcevalues[j+iteration*num] = defbuffer1.sourcevalues[j]
end
iteration = iteration+1
end
node[2].smu.source.output = node[2].smu.OFF
if defbuffer1.n == 0 then
print("\nNo readings in buffer\n")
else
for k=1,num do
--Se imprimen los valore de Vds Vs Ids para cada valor de Vg aplicado
print(string.format("%f\t%f\t\t%f\t%f\t\t%f\t%f\t\t%f\t%f",
sourcevalues[k],
readings[k], sourcevalues[k+num], readings[k+num], sourcevalues[k+num*2],
readings[k+num*2], sourcevalues[k+num*3], readings[k+num*3]))
end
end

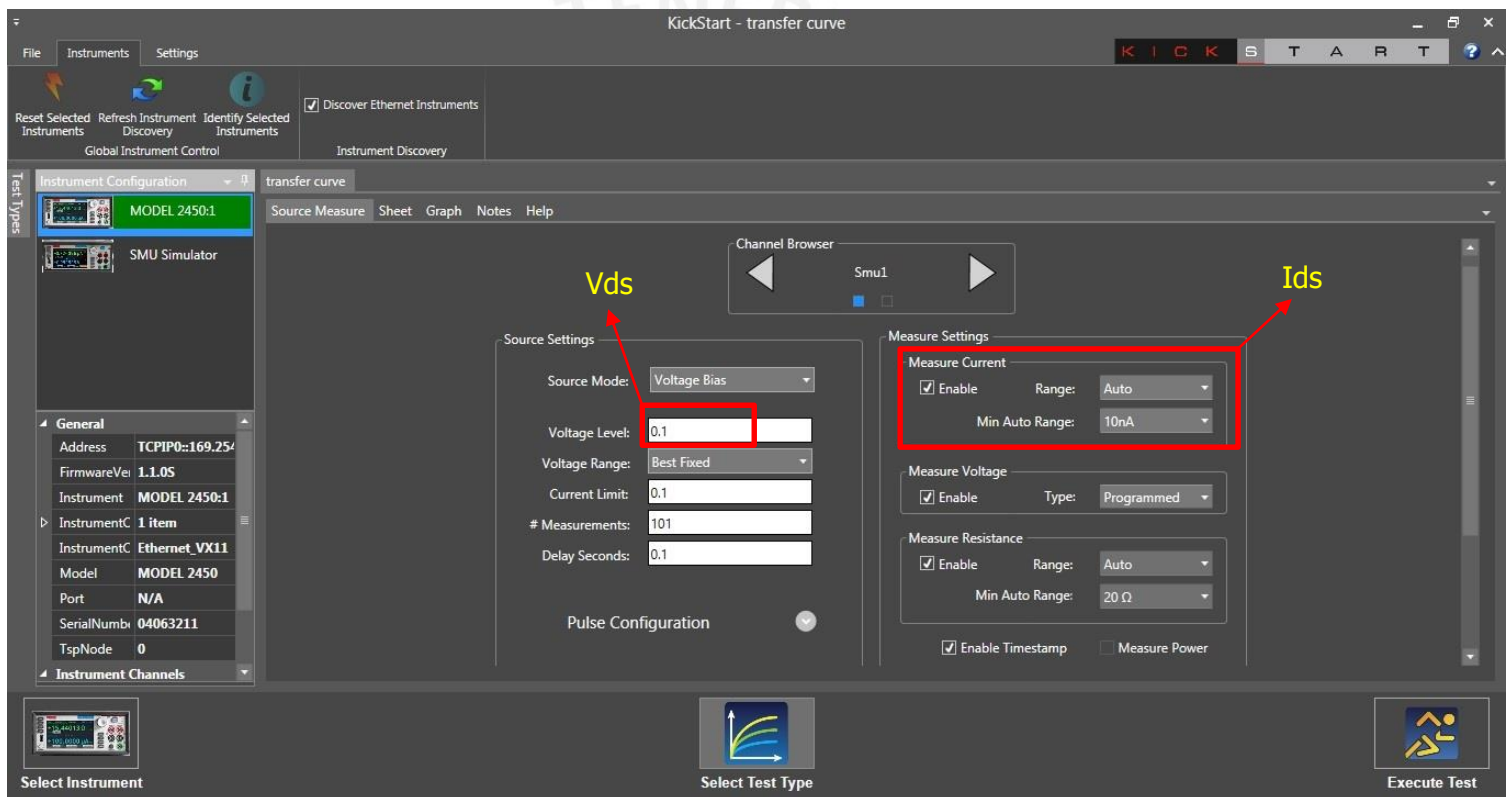
```

Finalmente, se exportan los datos obtenidos al Excel y/o Origin para para su posterior procesamiento y análisis.

Anexo II. Medición de las Características de transferencia

Una vez que se ha montado el sistema de medición en la configuración recomendada de la sección 2.2.3 se utiliza la siguiente secuencia en el programa KickStart para la obtención de las características de transferencia:

- Se selecciona el instrumento MODEL 2450:1 (Es importante configurar al SMU 1 como nodo 1 y al SMU 2 como nodo 2 como paso previo).
- Se selecciona el tipo de prueba o test en este caso Caracterización I-V.
- Se programan los parámetros del SMU 1 que controlan el voltaje V_{ds} que se aplica al transistor como sigue:



- Se programan los parámetros del SMU 2 que controlan el voltaje V_g que se aplica al transistor como sigue:



KickStart - transfer curve

File Instruments Settings

Reset Selected Instruments Refresh Instrument Discovery Identify Selected Instruments Discover Ethernet Instruments Global Instrument Control Instrument Discovery

transfer curve

Source Measure Sheet Graph Notes Help

MODEL 2450:1

SMU Simulator

Smu2

Source Settings

Source Mode: Voltage Sweep

Stepper Dual Sweep

Sweep Type: Linear

Start Voltage: -3

Stop Voltage: 3

Step Voltage: 0.06

Of Steps: 101

Voltage Range: Best Fixed

Current Limit: 0.1

Delay Seconds: 0.1

Measure Settings

Measure Current

Enable Range: Auto

Min Auto Range: 10nA

Measure Voltage

Enable Type: Programmed

Measure Resistance

Enable Range: Auto

Min Auto Range: 20 Ω

Enable Timestamp Measure Power

Measurement Speed Settings

Select Instrument

Select Test Type

Execute Test

En estas pestañas se muestran los datos de los parámetros seleccionados en tablas y gráficos respectivamente

Barrido de V_g

V_g

- Se ejecuta la prueba.
- Se exportan los datos obtenidos en Excel y/o Origin y se guardan para su posterior análisis.

Anexo III. Especificaciones técnicas del grafeno y los sustratos utilizados



Product Datasheet

Graphenea Monolayer Graphene film on various substrates

Graphene Film

Growth Method	CVD synthesis
Transfer Method	Clean transfer method
Quality Control	Optical Microscopy & Raman checked
Appearance (Color)	Transparent
Transparency	>97%
Appearance (Form)	Film
Coverage	>95%
Number of graphene layers	1
Thickness (theoretical)	0.345 nm
Field Effect Mobility on SiO ₂ /Si	2,000 cm ² /V-s
Hall Effect Mobility on SiO ₂ /Si	4,000 cm ² /V-s
Sheet Resistance	350 Ohms/sq.
Grain size	Up to 10 μm

Substrates

	si	siO ₂ /si
Type/Dopant	P/Bor	P/Bor
Orientation	<111>	<100>
Growth Method	CZ	CZ
Resistivity	1-30 ohm cm	<0.005 ohm cm
Thickness	525 +/- 25 μm	525 +/- 20 μm
Front Surface	polished	polished
Back Surface	etched	etched
Flats	2 SEMI	2 SEMI
Coating	--	300 nm thermal oxide on BOTH wafer sides

	Cu foil	Quartz
Thickness	18 μm	
Flatness		bow: 20um; Warp: 30um
Roughness		6 Å (polished side)
Polished		Double side polished



5. Referencias

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