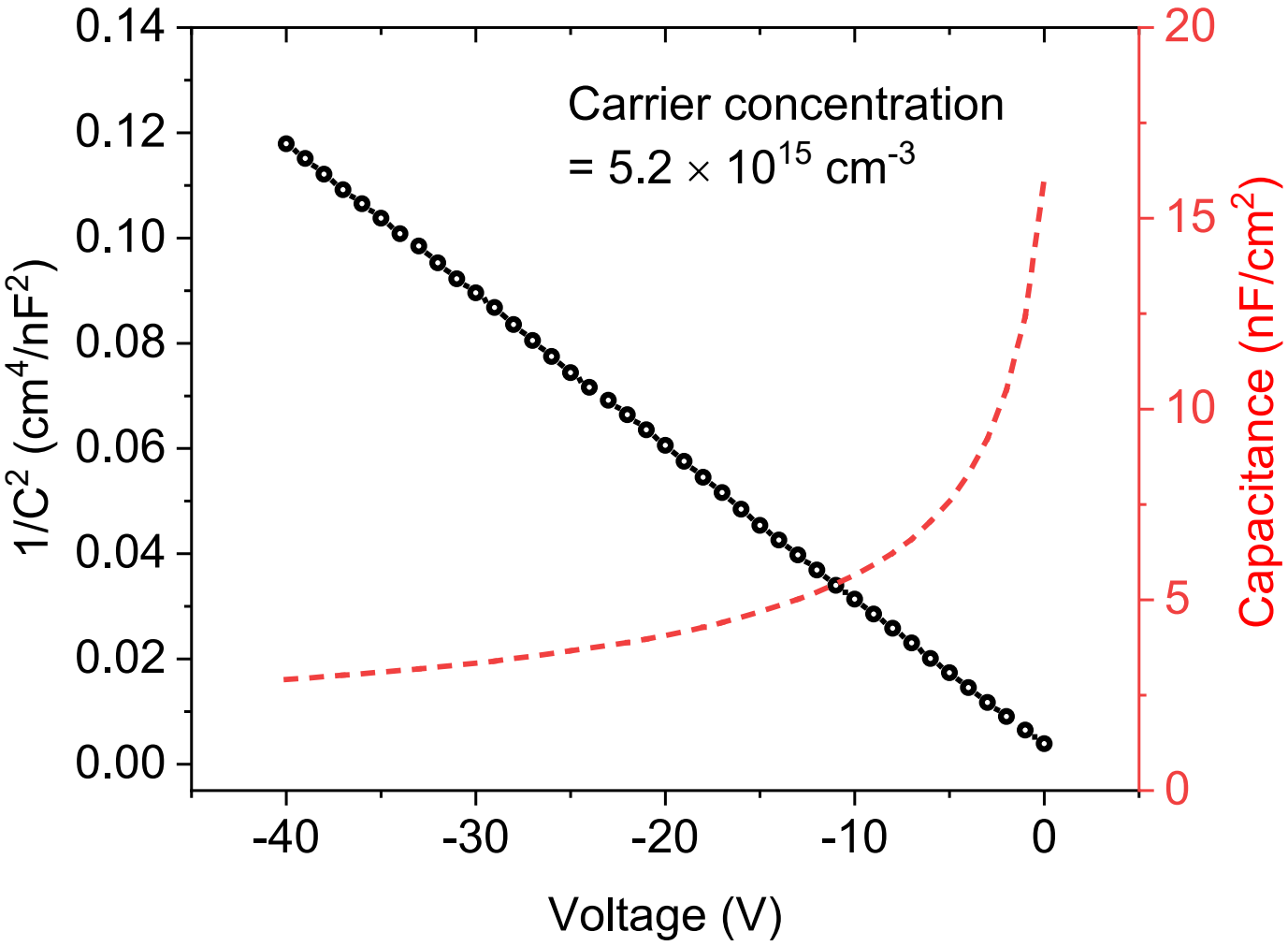
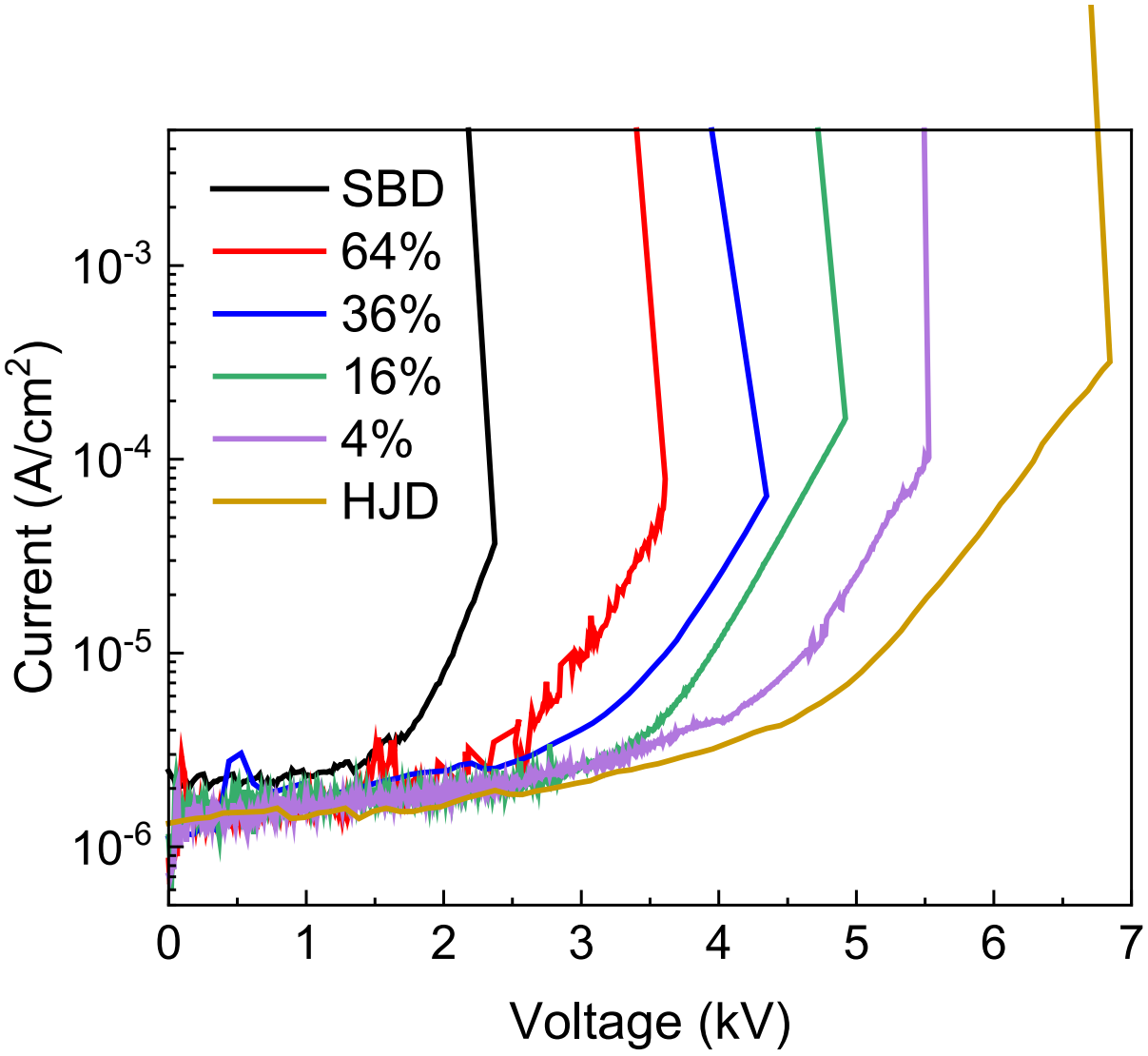
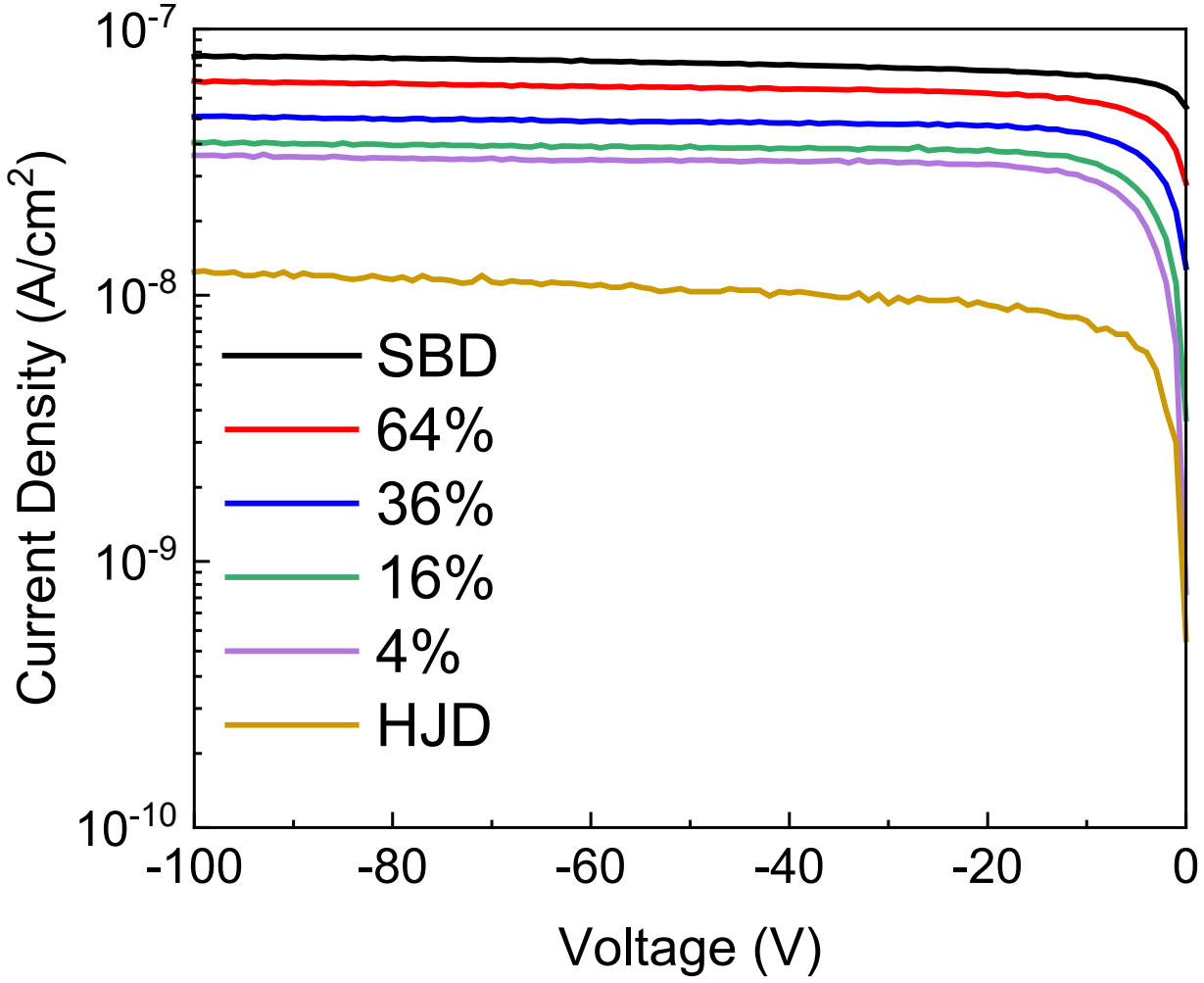
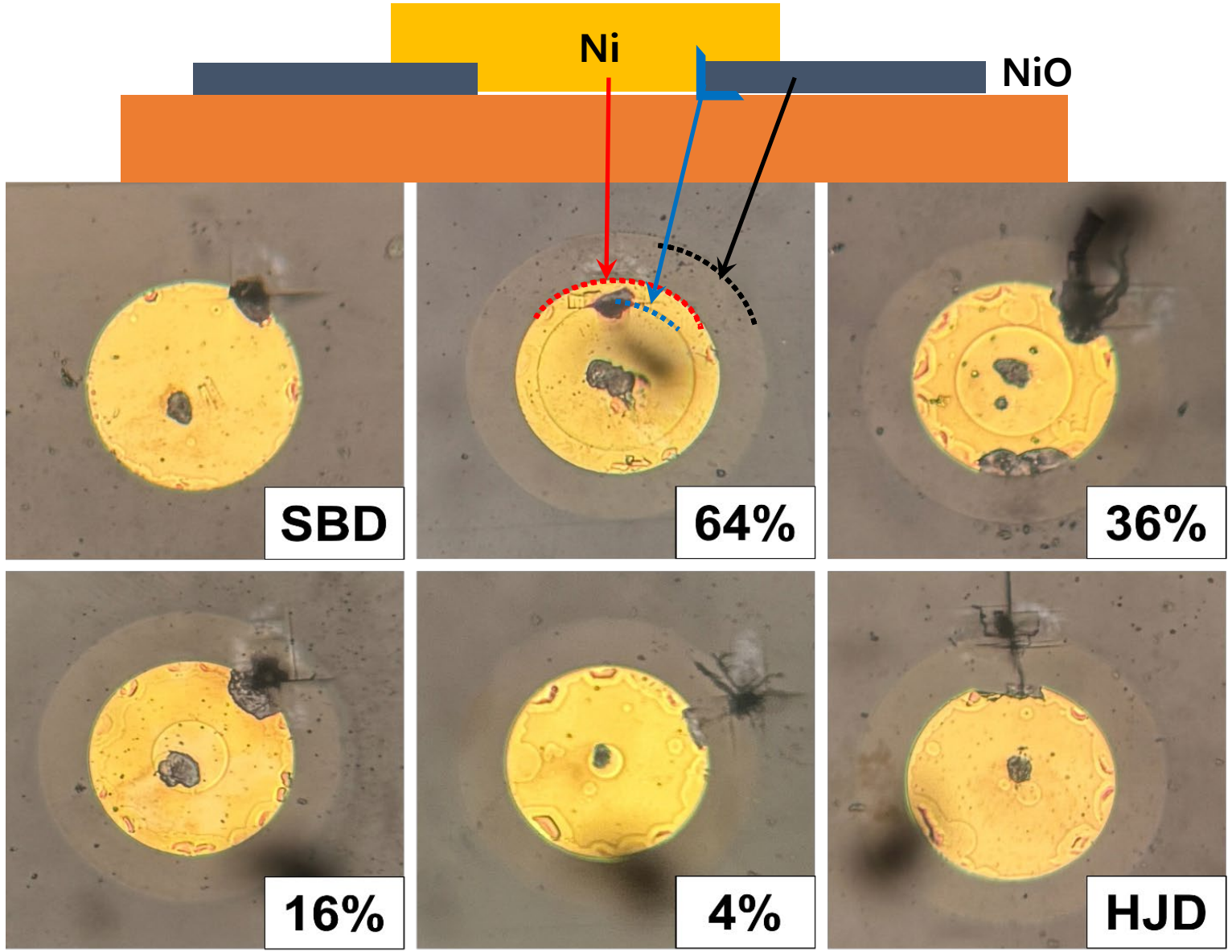
Supplementary Information (SI) for Journal of Materials Chemistry C.

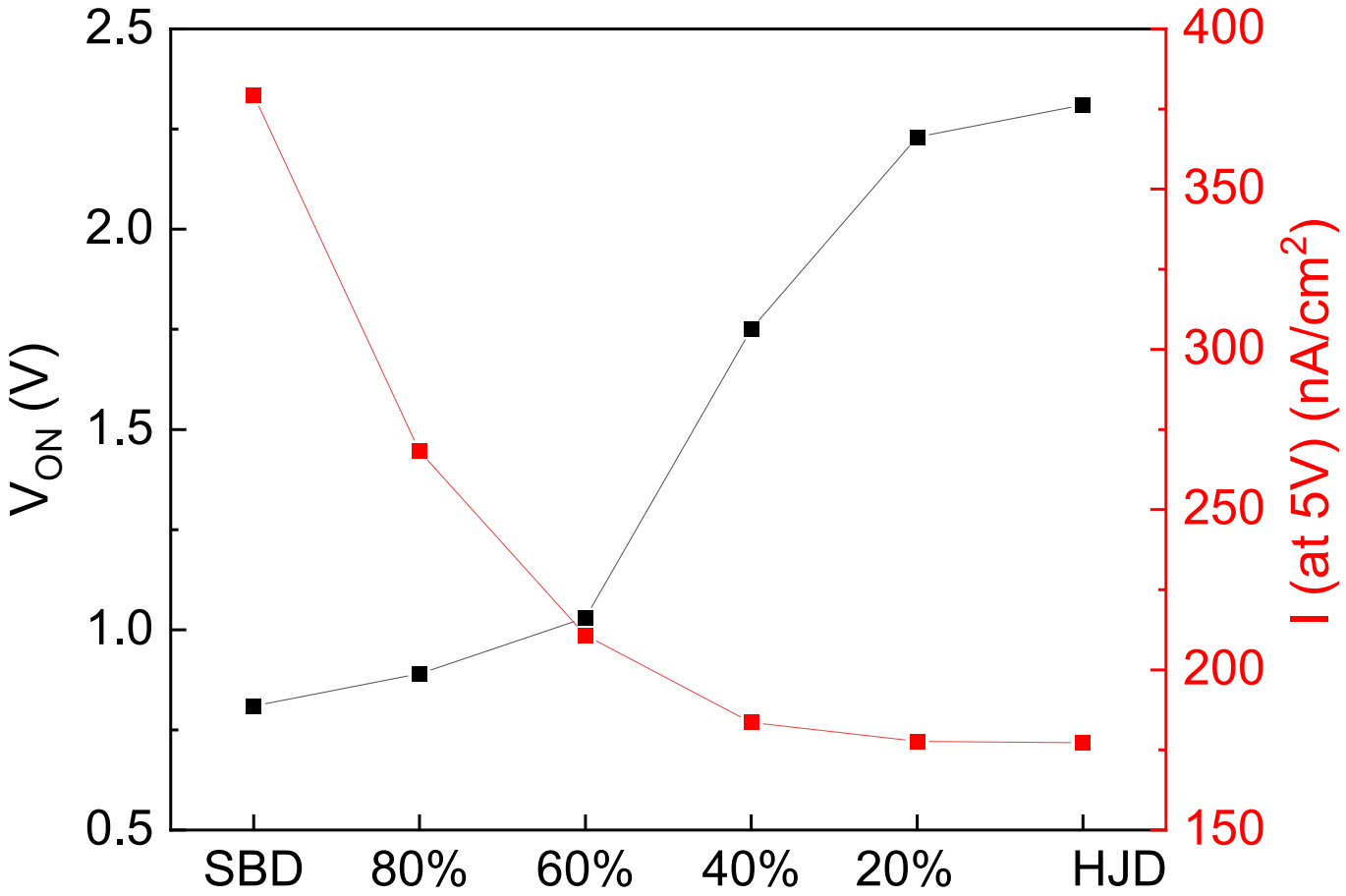
Supplemental file showing original data


Carrier concentration
= 5.2 × 10^15 cm^-3
1/C^2 (cm^4/nF^2)
Capacitance (nF/cm^2)
Voltage (V)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
20
15
10
5
0
-40
-30
-20
-10
0

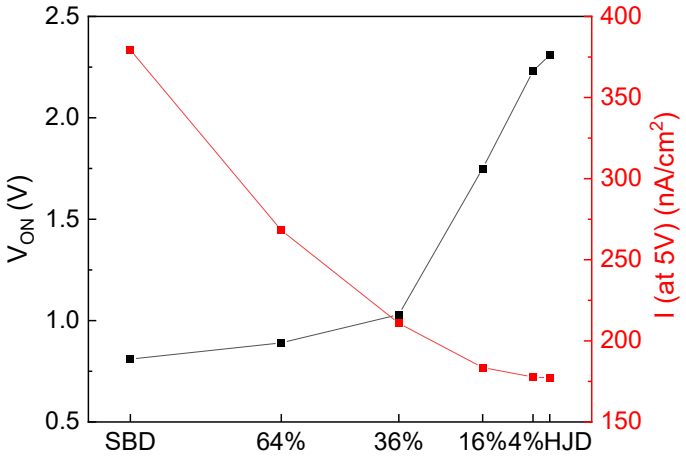

SBD
64%
36%
16%
4%
HJD
Current (A/cm^2)
10^{-3}
10^{-4}
10^{-5}
10^{-6}
0
1
2
3
4
5
6
7
Voltage (kV)

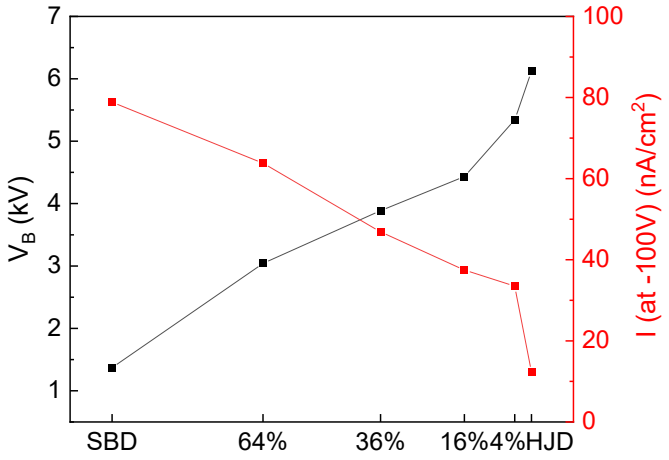

Current Density (A/cm^2)
10^{-7}
10^{-8}
10^{-9}
10^{-10}
SBD
64%
36%
16%
4%
HJD
-100
-80
-60
-40
-20
0
Voltage (V)

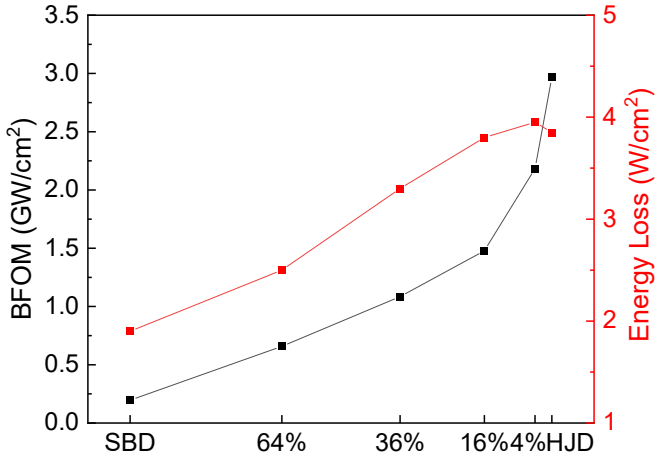

Ni
NiO
SBD
64%
36%
16%
4%
HJD


2.5
2.0
1.5
1.0
0.5
V_{ON} (V)
400
350
300
250
200
150
I (at 5V) (nA/cm^2)
SBD
80%
60%
40%
20%
HJD

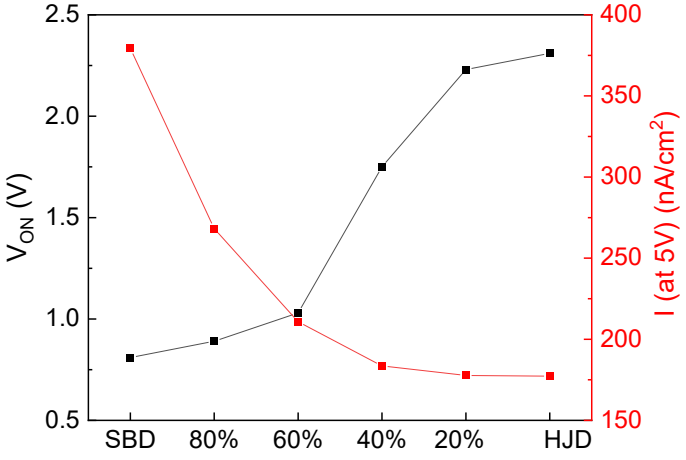
The x-axis shows the percentage of the area of the Schottky contact.

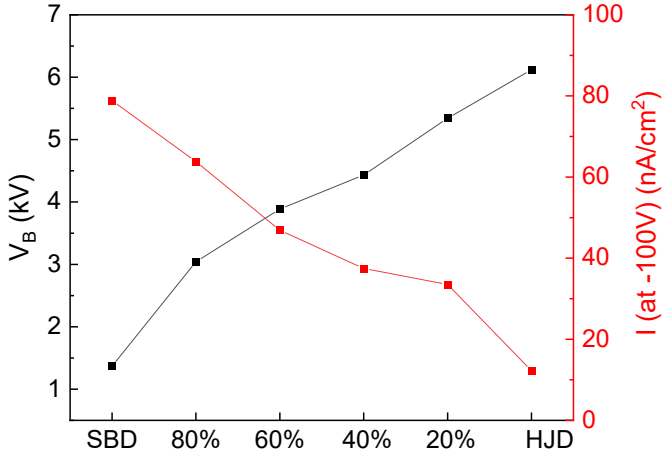


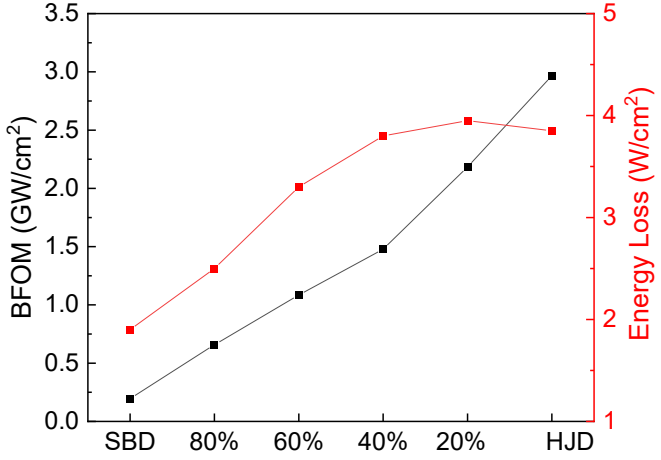




The x-axis shows the percentage of the diameter of the Schottky contact.



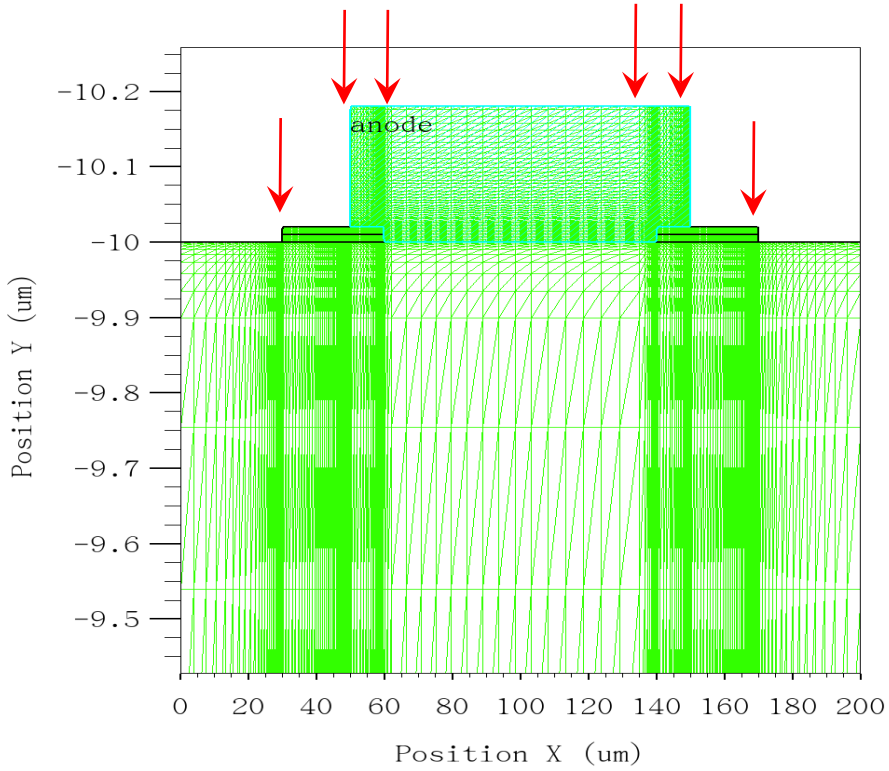


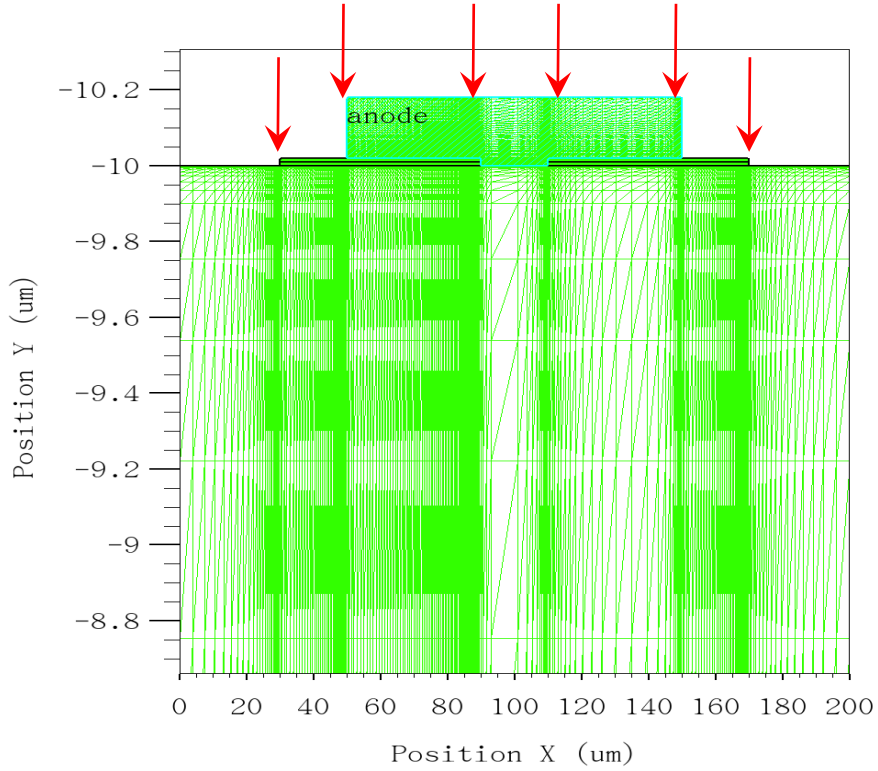


Energy loss = $D*P_{ON}+(1-D)*P_{OFF}= D*V_F$(at 100A/cm^2)*100 A/cm^2+(1-D)*100V*I(at-100V), D = Duty cycle (assume 1%)

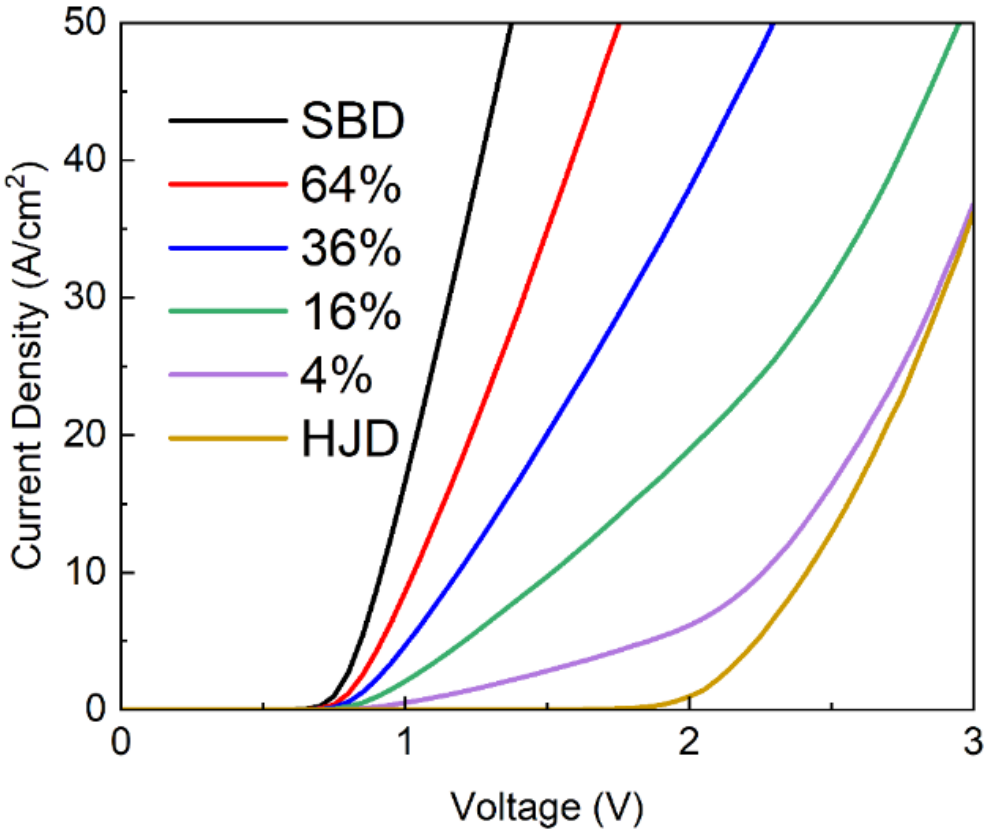
Meshing Process

The number of nodes should be increased at the interfaces, as illustrated in the figure.





one simulation process ⟶ 2-3 hours



Measured JV

Why we have two linear regions for 16 % and 4 %?

Plan

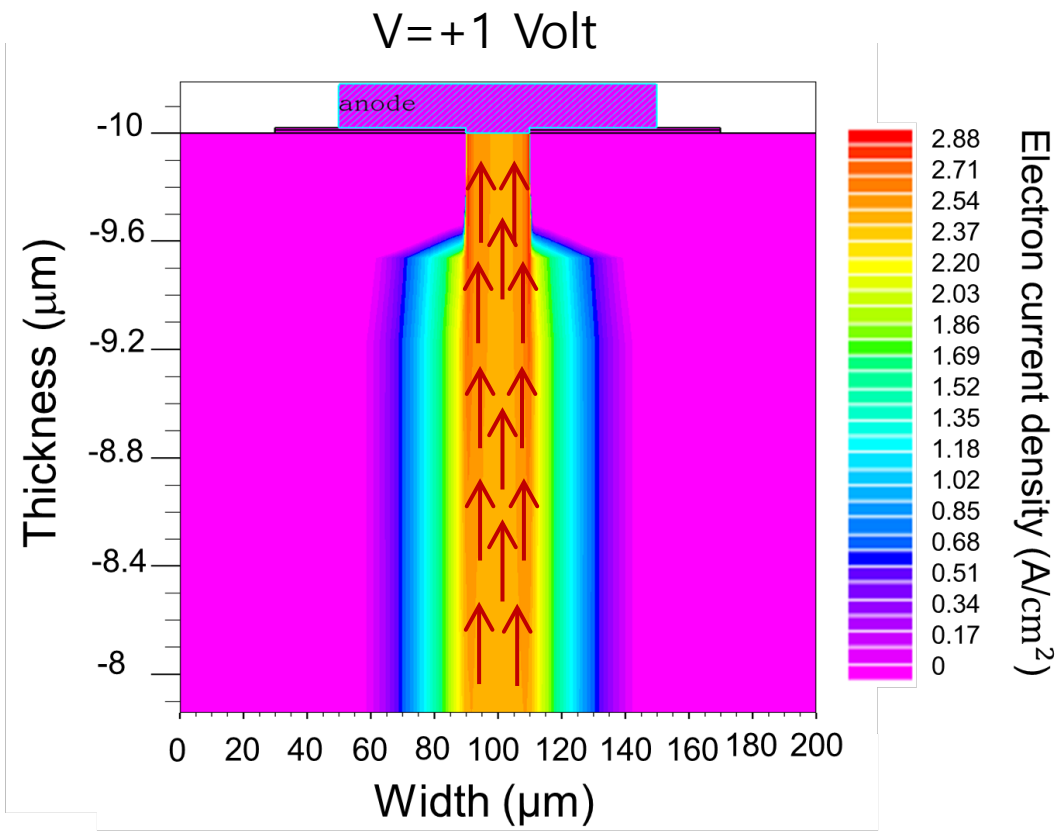
I will extract the electron current density for the 16% and 4% cases and compare them with the 64% case. I expect there to be two primary electron transfer pathways from Ga_2O_3 to Ni in the 16% and 4% scenarios:

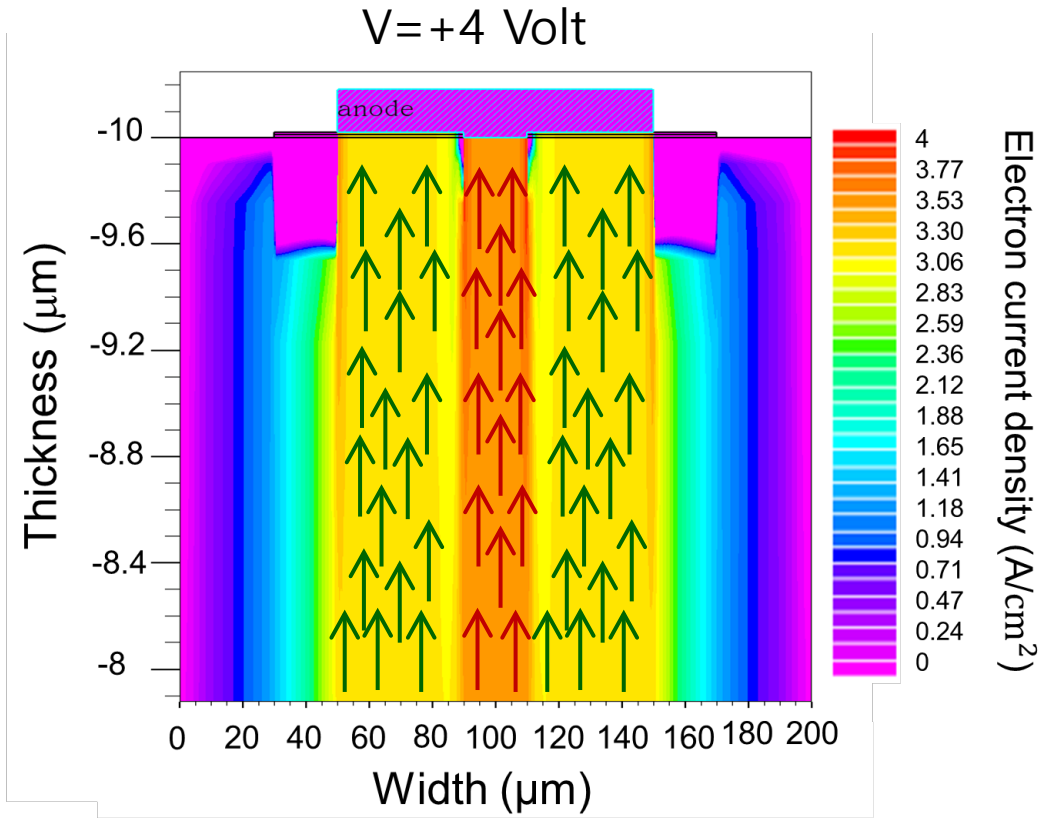
Direct Transfer: From Ga_2O_3 to the Ni contact through the small 20 μm ring.

Indirect Transfer: From Ga_2O_3 to the ultrathin NiO layers, then to the Ni contact.

These transfer mechanisms can influence the formation of two linear regions in the current density profiles.

4 % (20 μm) Junction Barrier Schottky diode

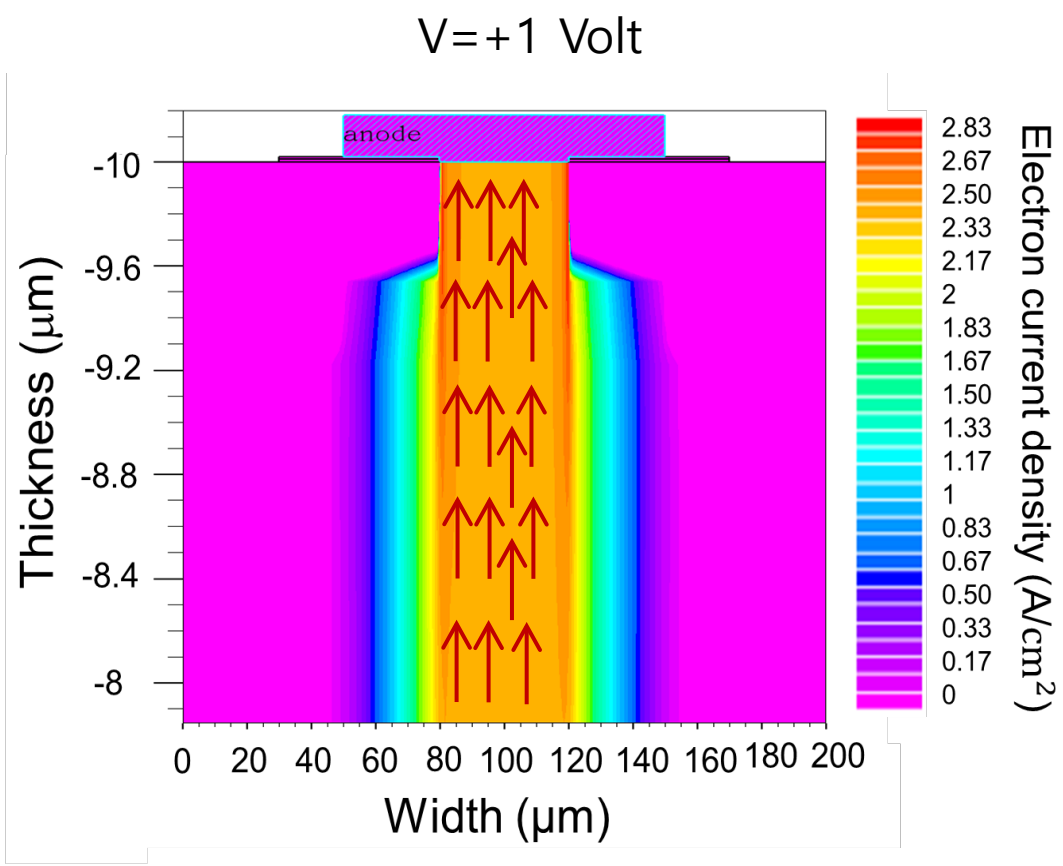


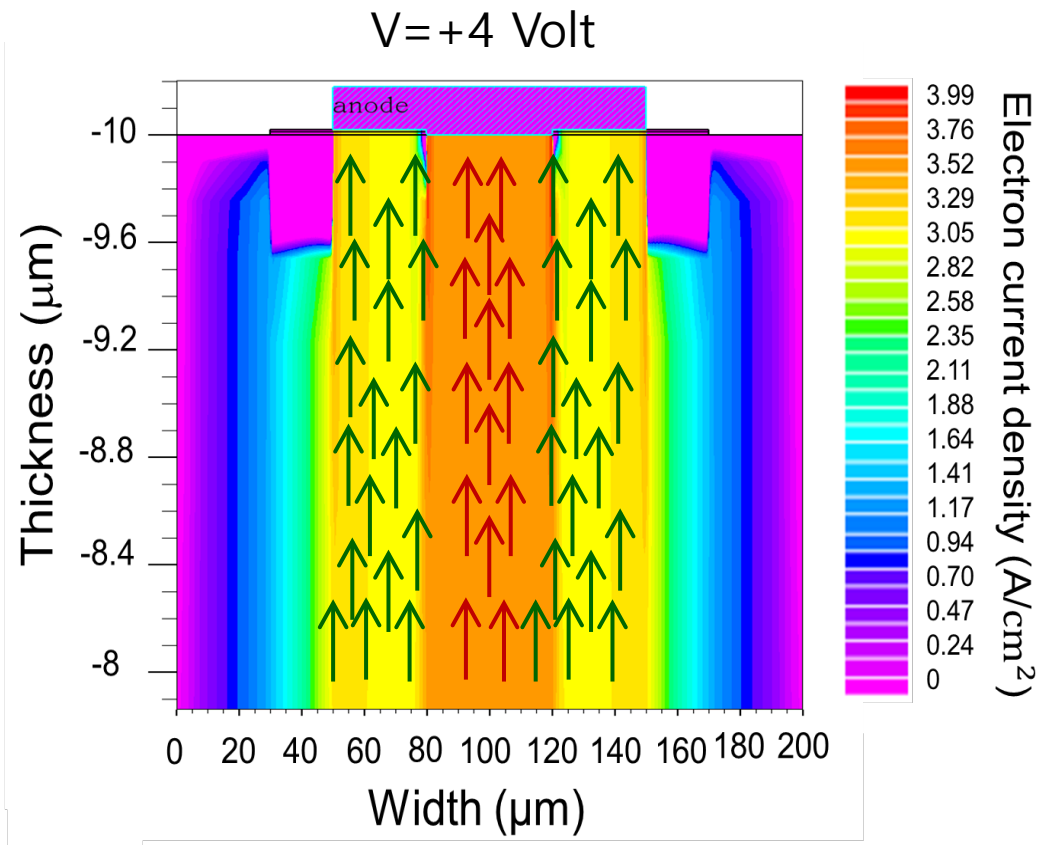


→ Ni/β-Ga_2O_3thermionic emission

→ Ni/NiO/β-Ga_2O_3thermionic emission

16 % (40 μm) Junction Barrier Schottky diode

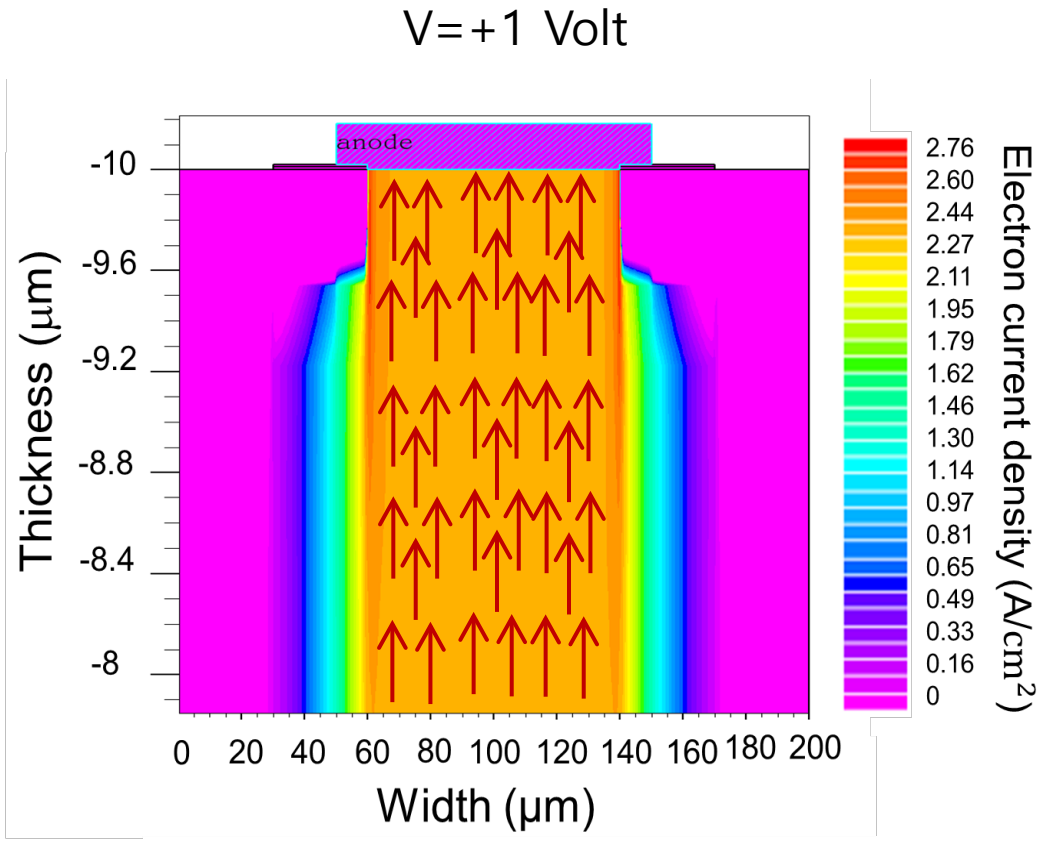


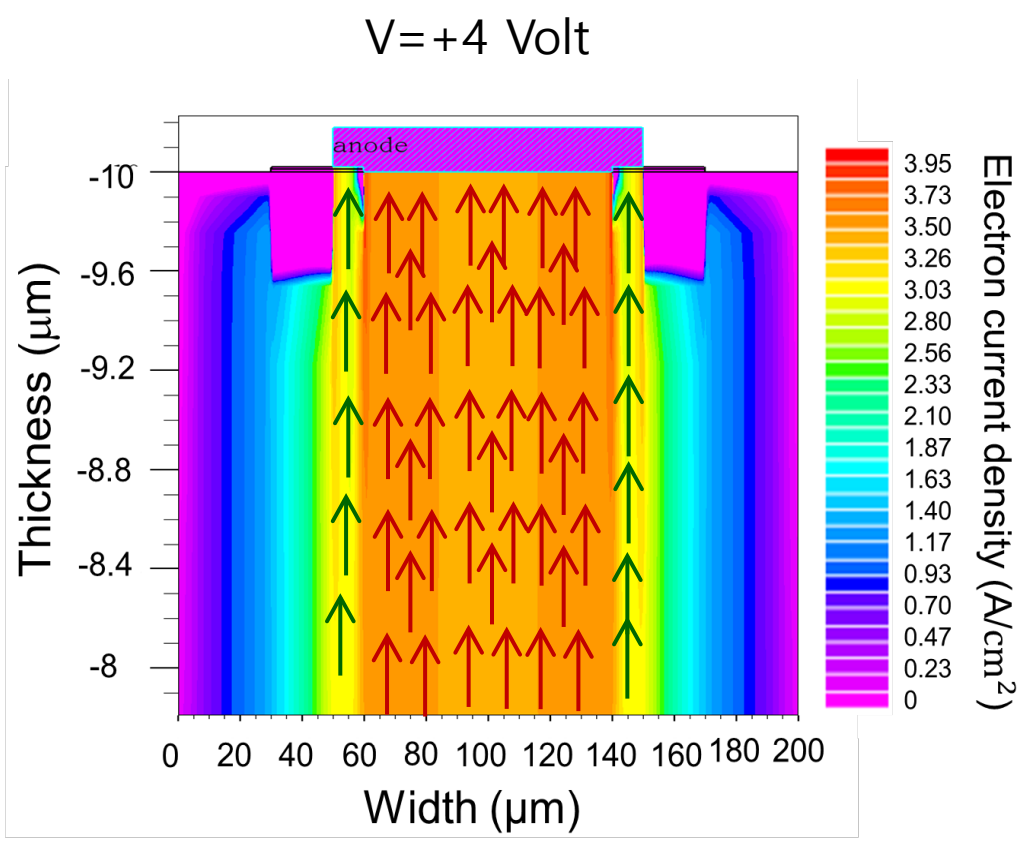


→ Ni/β-Ga_2O_3thermionic emission

→ Ni/NiO/β-Ga_2O_3thermionic emission

64 % (80 μm) Junction Barrier Schottky diode





→ Ni/β-Ga_2O_3thermionic emission

→ Ni/NiO/β-Ga_2O_3thermionic emission

Comparison of Electron Transfer in Junction Barrier Schottky Diodes

Key Findings:

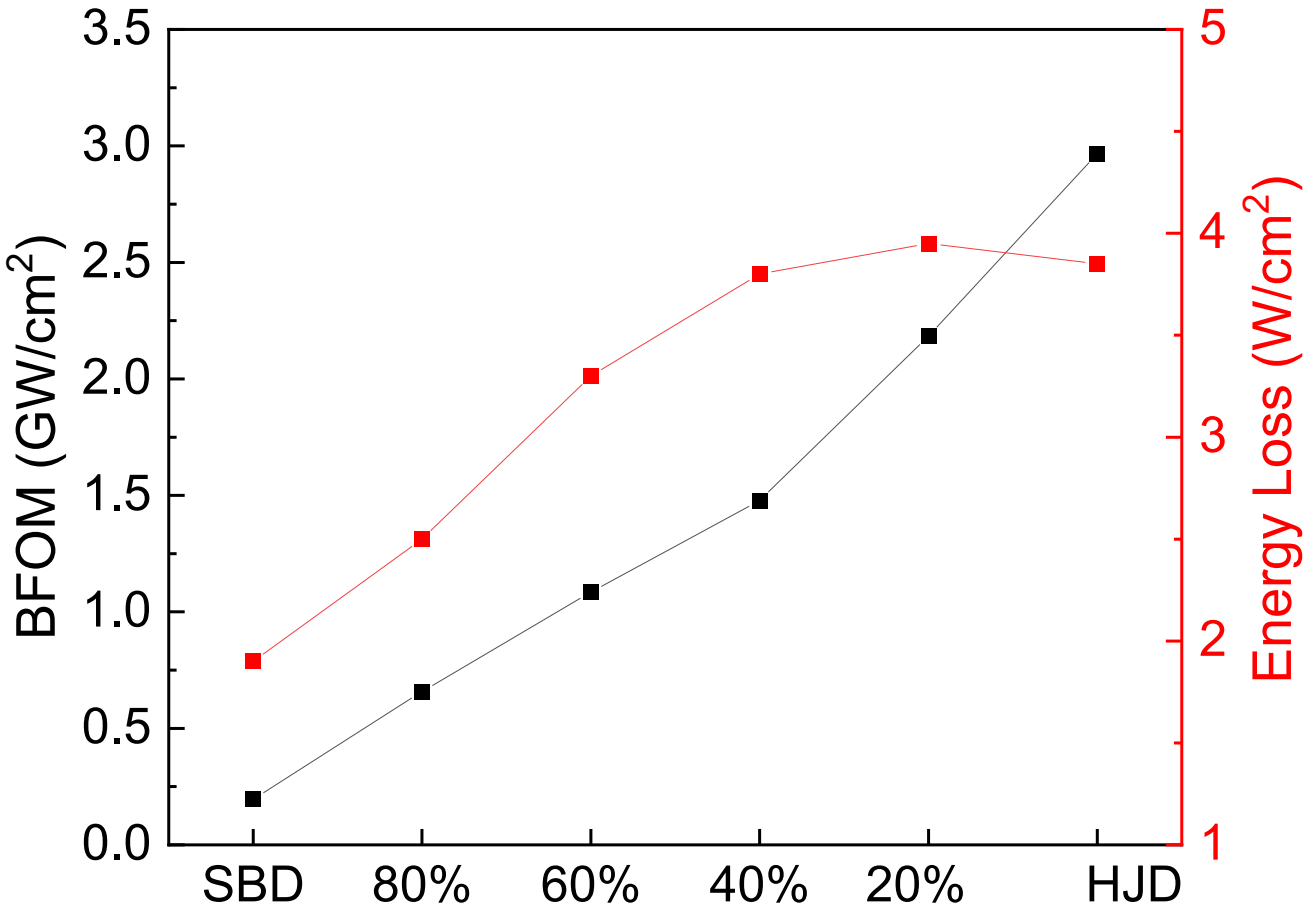
Direct Transfer Efficiency:

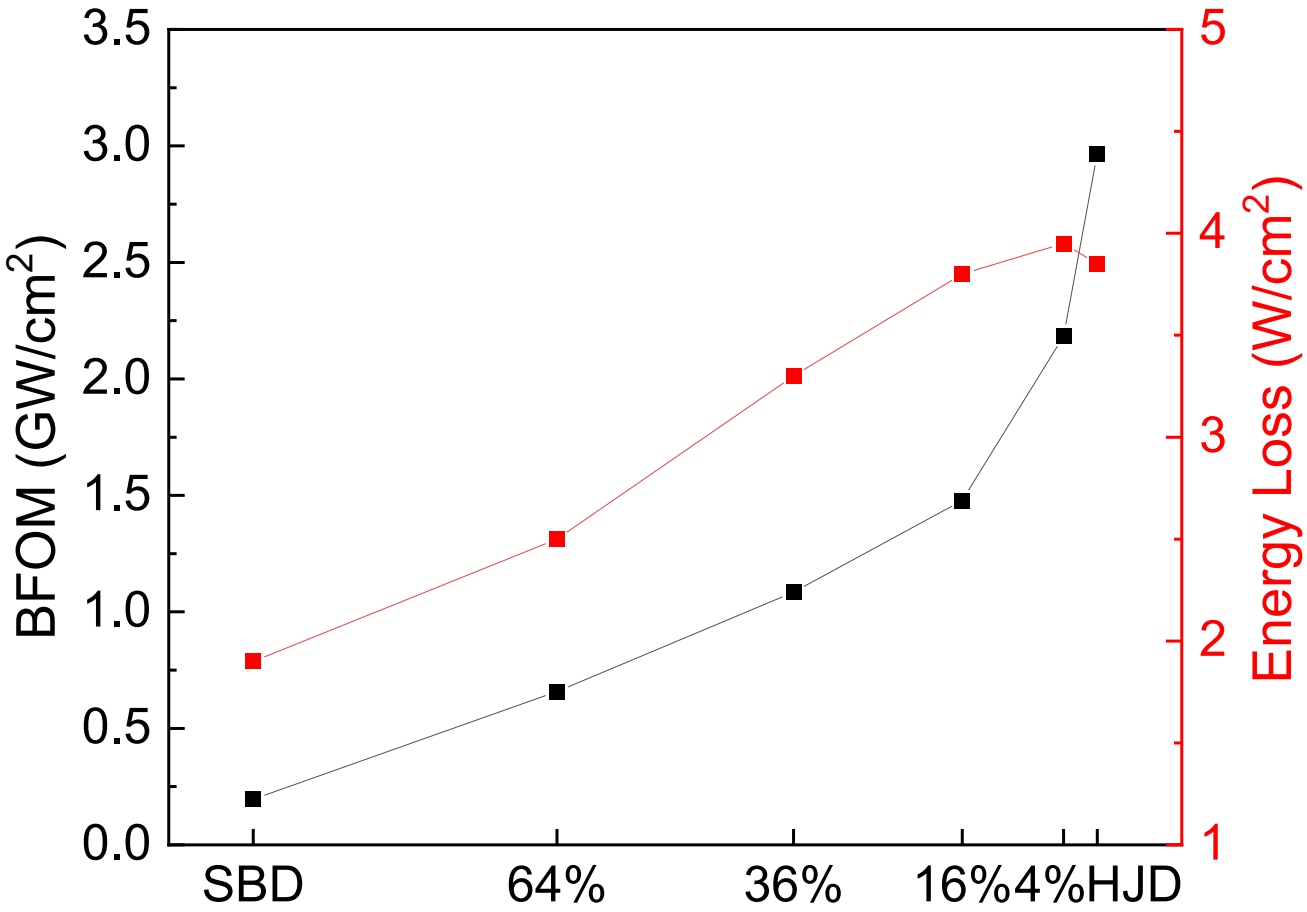
The direct transfer for the 64% Junction Barrier Schottky diode is significantly higher compared to the 16% and 4% diodes.

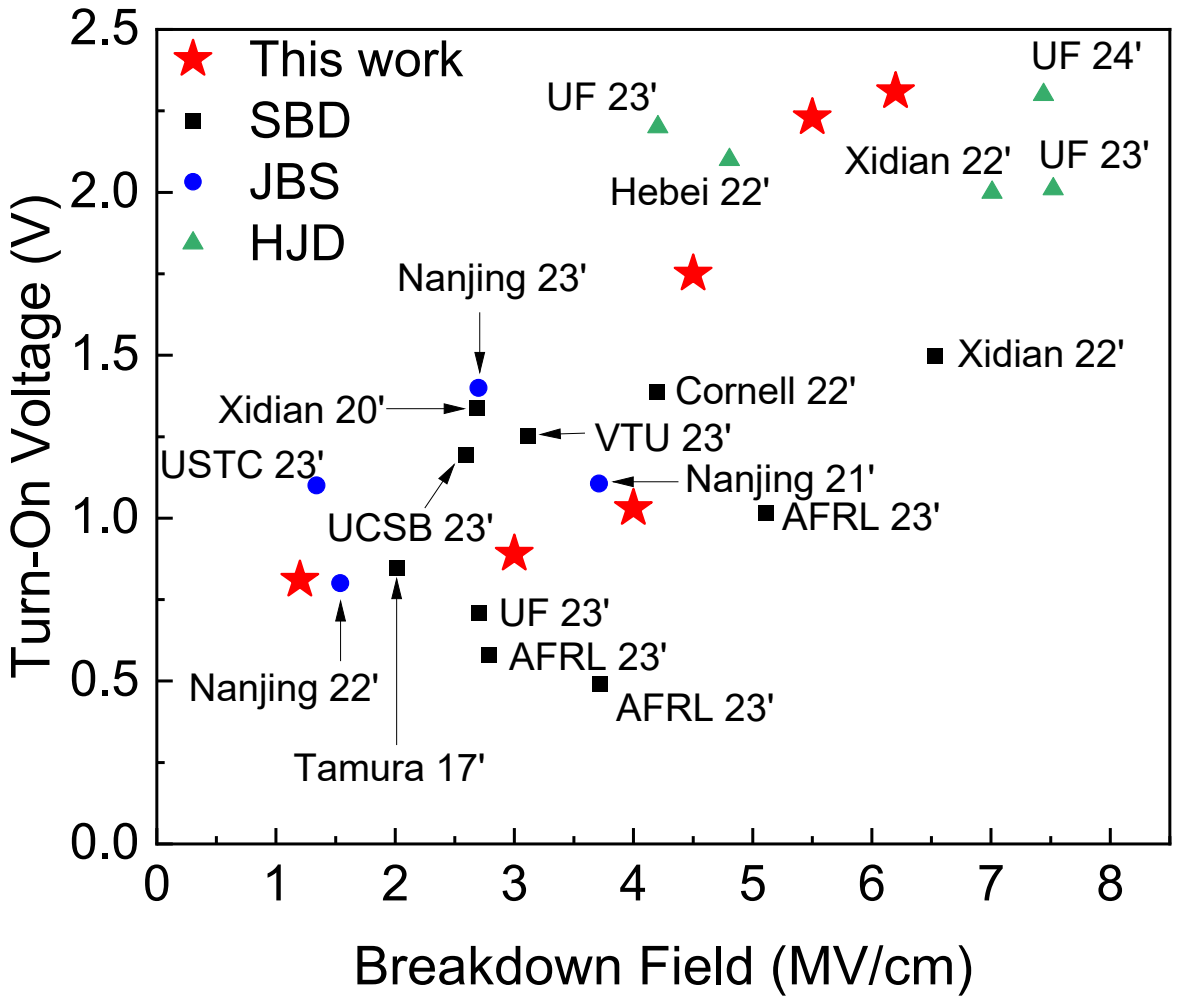
Impact on Linear Regions: For the 16% and 4% diodes, the presence of two linear regions can be attributed to the effect of indirect transfer mechanisms.

Conclusion:

Indirect Transfer Mechanism: In the 16% and 4% Junction Barrier Schottky diodes, the thermionic emission of electrons from Ga_2O_3 to the ultrathin NiO layers, followed by transfer to the Ni contact, explains the formation of the two linear regions observed in the current density profiles.


3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
BFOM (GW/cm2)
5
4
3
2
1
Energy Loss (W/cm2)
SBD
80%
60%
40%
20%
HJD


3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
BFOM (GW/cm2)
5
4
3
2
1
Energy Loss (W/cm2)
SBD
64%
36%
16%
4%
HJD


This work
SBD
JBS
HJD
Turn-On Voltage (V)
Breakdown Field (MV/cm)
2.5
2.0
1.5
1.0
0.5
0.0
0
1
2
3
4
5
6
7
8
UF 24'
UF 23'
Xidian 22'
UF 23'
Hebei 22'
Nanjing 23'
Xidian 22'
Cornell 22'
Xidian 20'
VTU 23'
USTC 23'
Nanjing 21'
AFRL 23'
UCSB 23'
UF 23'
AFRL 23'
Nanjing 22'
AFRL 23'
Tamura 17'