Wide Bandgap Semiconductor Lab

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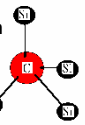
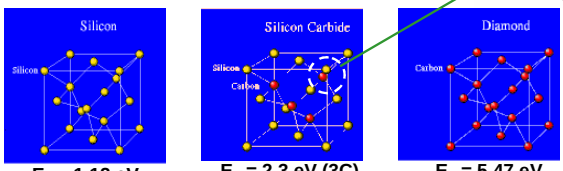
Why Silicon Carbide?

Introduction:

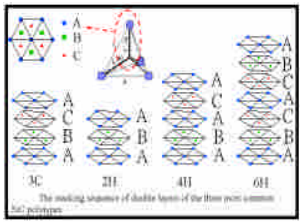
Silicon Carbide is a binary compound of Si and C. Carbon atoms are surrounded by 4 neighboring silicon atoms and vice versa. The energy gap (Eg) of SiC is between Silicon and Diamond (single crystalline carbon).





E_g = 1.12 eV | E_g = 2.3 eV (3C) | E_g = 5.47 eV

There are many different stacking sequences of Si-C bi-layers in SiC called polytypes. In the literature, there are more than 150 different polytypes found. Each polytype displays different characteristics. The most popular polytypes in research are 3C, 4H and 6H.



Source: www.ifm.liu.se/matephys

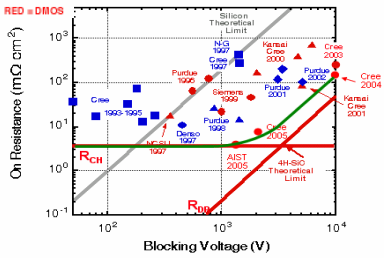
Advantage of SiC:

Silicon carbide has many superior properties such as wide energy gap, high thermal conductivity, high electron saturation velocity, and high-breakdown electric field. These properties make it a candidate of choice for fast switching, high-temperature and high-power applications.

Comparison of Silicon and Silicon Carbide (3C and 4H)

	Si	3C-SiC	4H-SiC
Energy gap (eV)	1.12	2.36	3.26
Breakdown field (MV/cm)	0.25	2.0	2.2
Saturation velocity(10^7 cm/s)	1.0	2.5	2.0
Electron mobility (cm^2/V-s)	1350	1000	950
Hole mobility (cm^2/V-s)	480	40	120
Dielectric constant	11.9	9.7	9.7
Thermal conductivity (W/cm-K)	1.5	4.9	4.9
Intrinsic carrier concentration (cm^{-3})	$1.5*10^{10}$	1.2	$9.43*10^{-9}$

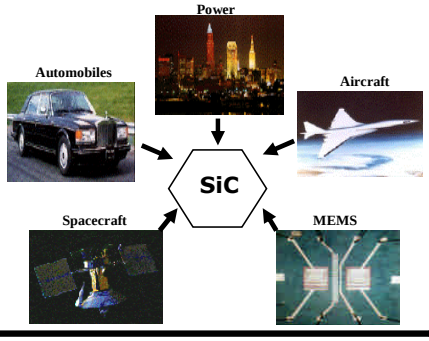
SiC MOSFET Power Device



The performance of the reported SiC devices has far exceeded the "Silicon limit". Shown in the left figure, SiC MOSFETs with blocking voltage as high as 10kV have been demonstrated.

Applications:

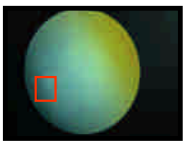
The possible applications of SiC devices include automotive electronics, power conversion, avionics, RF power amplification, sensors and actuators ....etc.



What we do

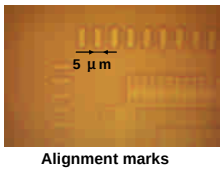
Experiment | Simulation

Silicon carbide wafer

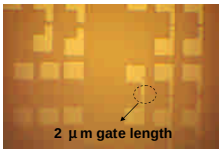


Strains in SiC wafers can be observed using cross polarization imaging

Lithography

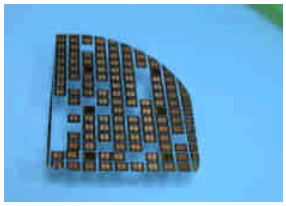


Alignment marks



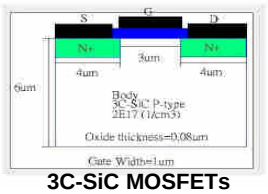
Patterns of MOSFETs

Using the equipments in NTHU semiconductor laboratory, we can produce features as small as 2 μm wide. Through a sequence of processes, hundreds of prototype devices can be made.



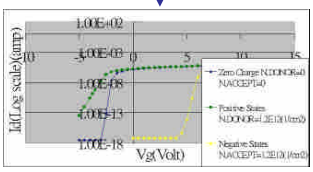
The fabricated devices will be diced.

Devices will then be put in packages and tested.

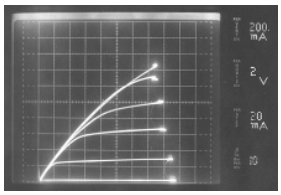


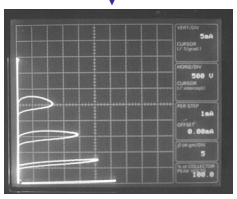
3C-SiC MOSFETs

we can use simulation tools such as Medici to explore innovative device structures and to understand device physics.



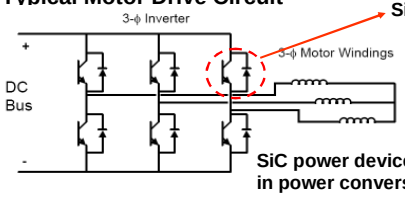
The key parameters that effect the device characteristics will be extracted and studied.





Simulation and experiment together will help us improve design and fabricate better SiC power devices to take full advantage of the material properties.

Typical Motor Drive Circuit



SiC Power Devices

SiC power devices can be implemented in power conversion systems to boost efficiency up.