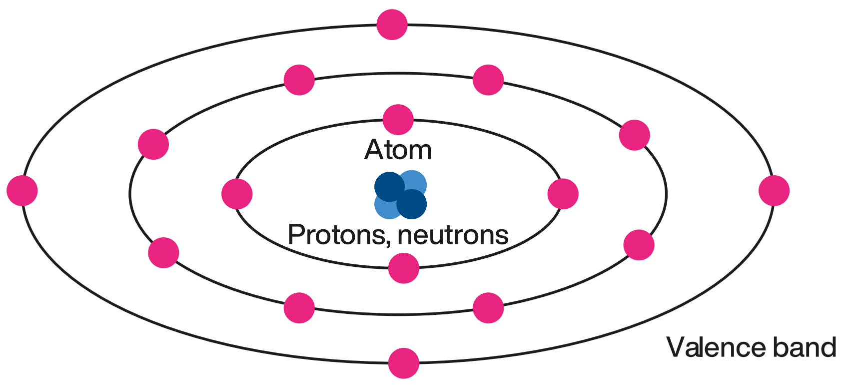
Reference Guide to Wide Bandgap Semiconductors

Background

In a semiconductor, current flows thanks to the availability of free electrons. These electrons are arranged in bands around a nucleus. With external energy applied, electrons jump between the outermost valence and conduction bands and current flows. The distance, or energy difference, between the valence and conduction bands is known as the bandgap.

Wide band gap (WBG) semiconductors are created from material that has a larger bandgap than traditional semiconductors. The valence-conduction bandgap is measured in electronVolts (eV) and is a key factor defining the properties of a semiconductor.



Bandgap = 0 or very small: Conductor, such as copper wire. Valence and conduction bands overlap
Bandgap < 2 eV: Conventional silicon semiconductors, such as a transistor or diode
Bandgap > 2 eV: WBG material semiconductors
Bandgap > 4 eV: Insulator

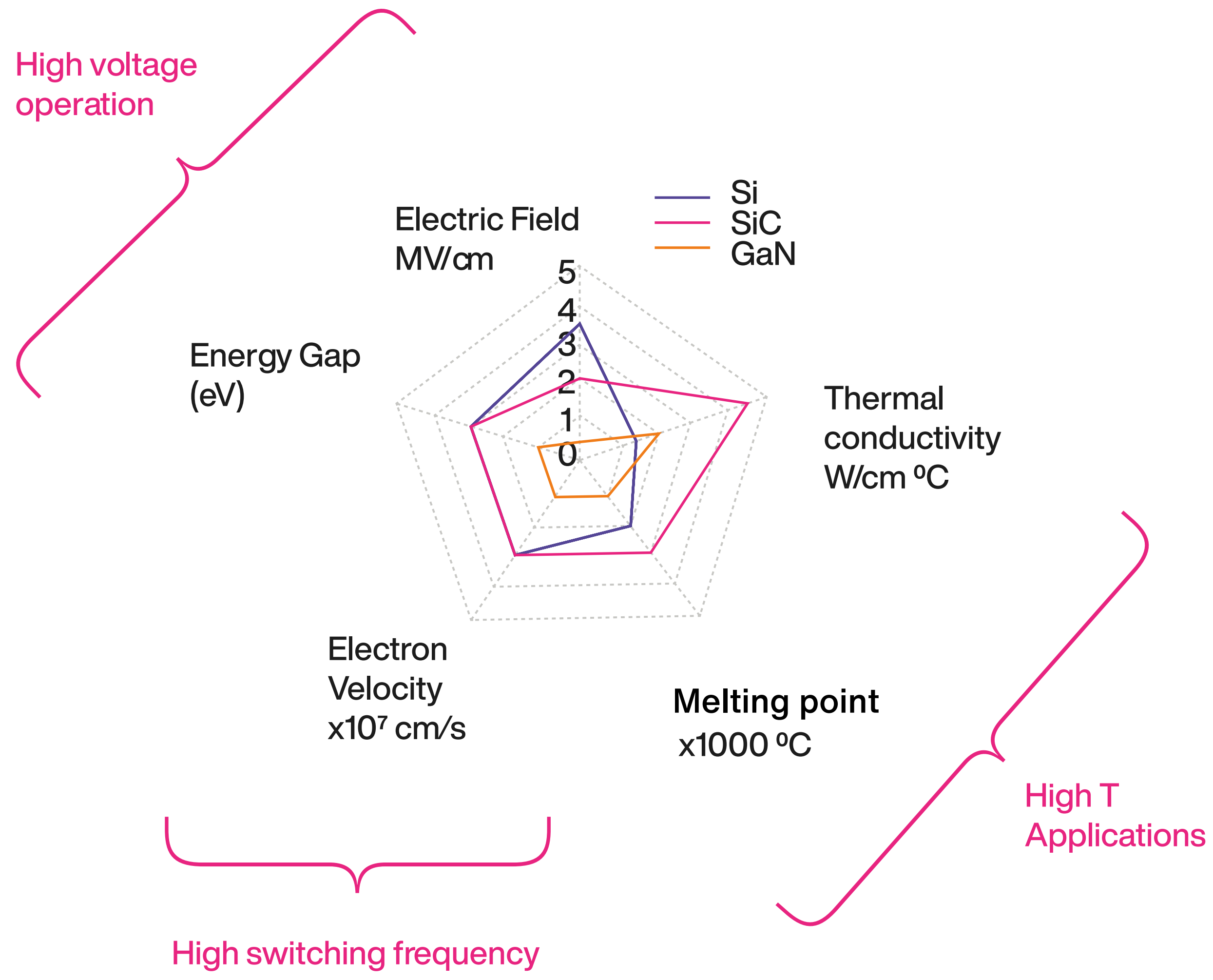
WBG semiconductors, associated bandgap and typical applications

Electric properties of elements depend on the group in the periodic table they are in. For compound semiconductor materials, the groups of the constituting elements (e.g. III-V) are the determining factors. and conduction bands is known as the bandgap.

Material	Bandgap in eV (@300 K)	Typical Application
IV-IV semiconductor		
SiC	3.03	high-voltage and high-temperature applications, early yellow and blue LEDs
III-V semiconductors		
GaN	3.37	blue LEDs and laser diodes
InGaN	0.7 – 3.37	modern blue and green LEDs
BN	5.8	blue LEDs (experimental)
AIN	6.2	ultraviolet LEDs with wavelengths down to 200–250 nm
II-VI semiconductor		
ZnO	3.37	conductive films in LCD displays and solar panels
Element		
C (as Diamond)	5.46 – 5.6	Quantum data storage, heat sinks

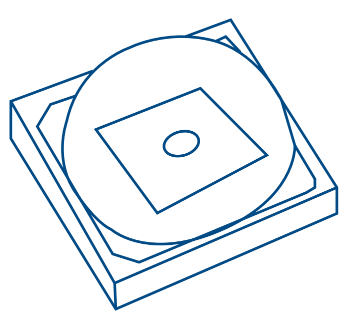
Comparison of Si, SiC and GaN physical parameters:

Compared to silicon (Si) devices, WBG devices typically operate at higher voltage, frequency and temperature, increasing efficiency and reducing overall pcb size.



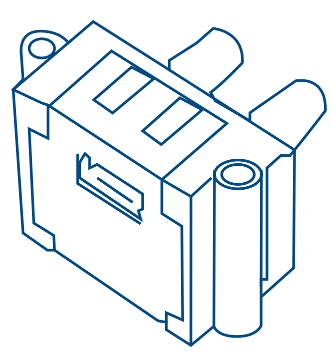
Types of applications

LEDs



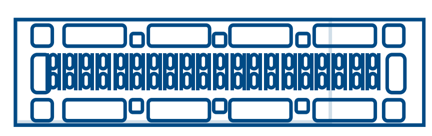
WBG materials are more useful at shorter wavelengths than other semiconductors since the bandgap determines the wavelength at which LEDs emit light.

MEMS transducers



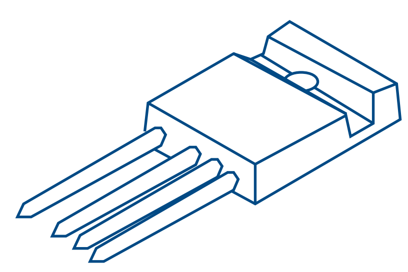
Large piezoelectric effects allow WBG materials to be used as MEMs transducers

Power conversion



The high breakdown voltage of WBG materials is due to a larger electric field required to generate carriers through impact. Both gallium nitride and silicon carbide are materials well suited for high-temperature and high-voltage applications such as power conversion

Integrated circuit design



A high-electron-mobility transistor (HEMT) is a field-effect transistor incorporating a junction between two materials with different bandgaps as the channel instead of a doped region. HEMTs are used in integrated circuits as digital on-off switches or amplifiers.