Development of SiC Power Semiconductor Devices

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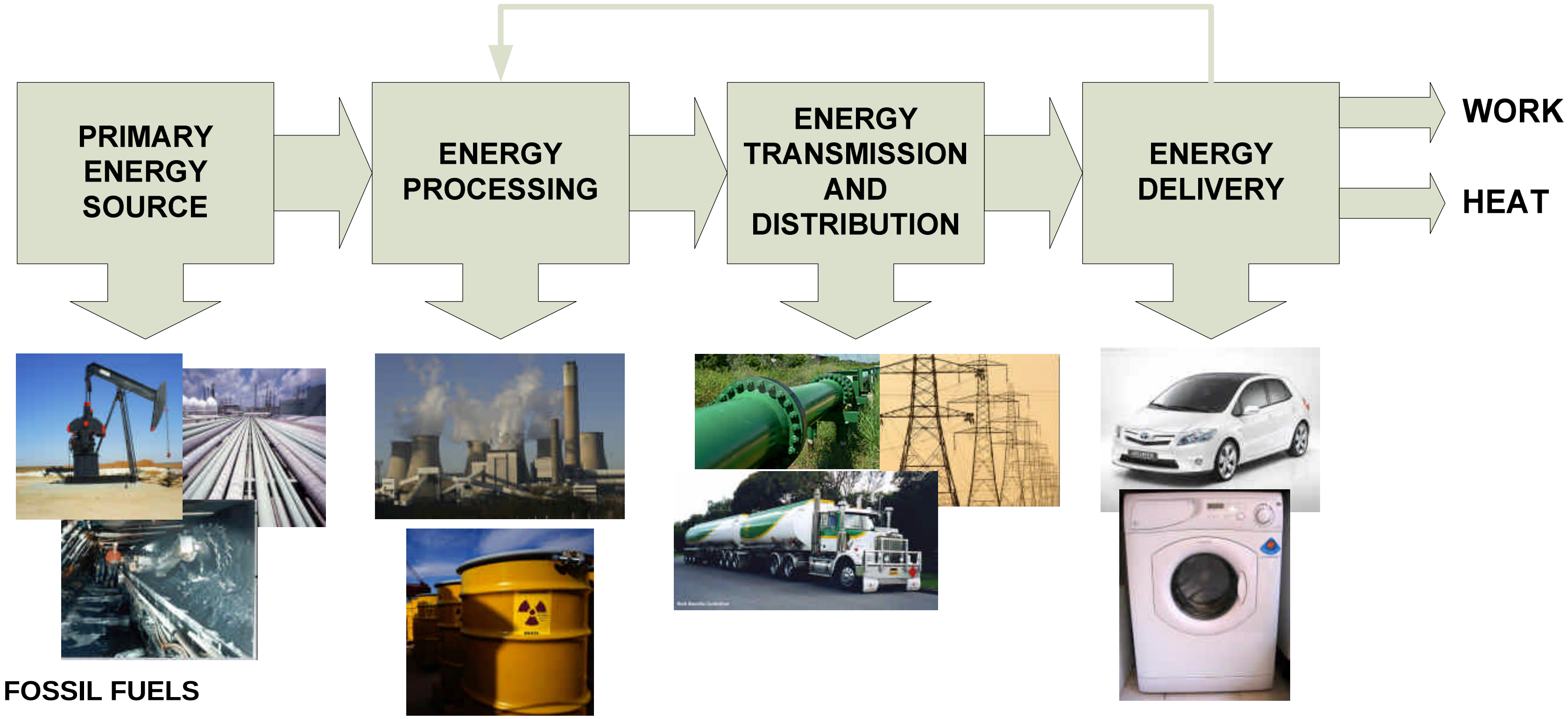
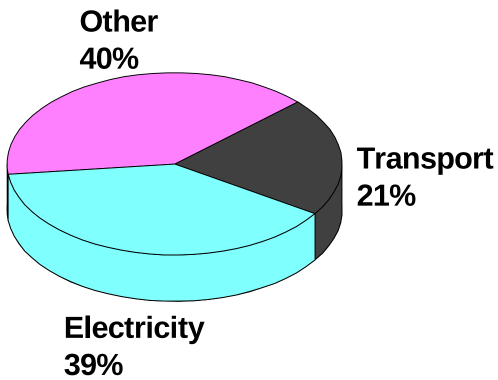
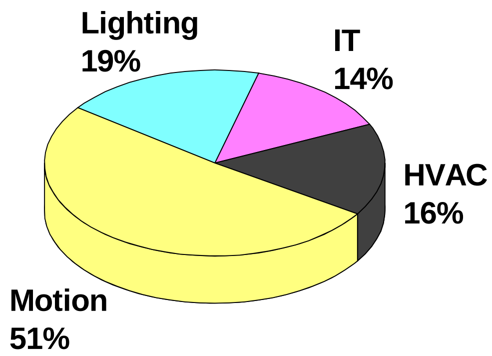
25th November 2009

The Energy Supply Chain 2008

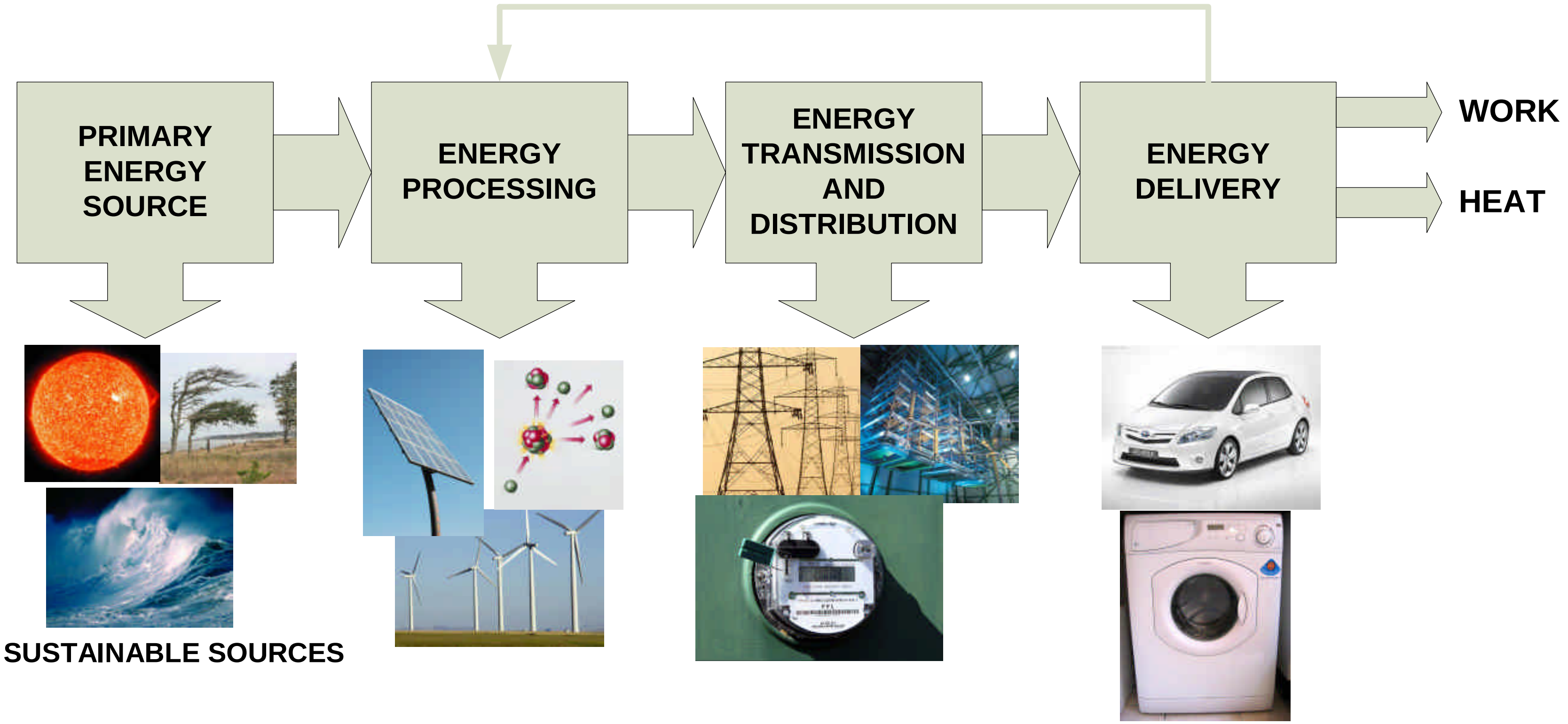


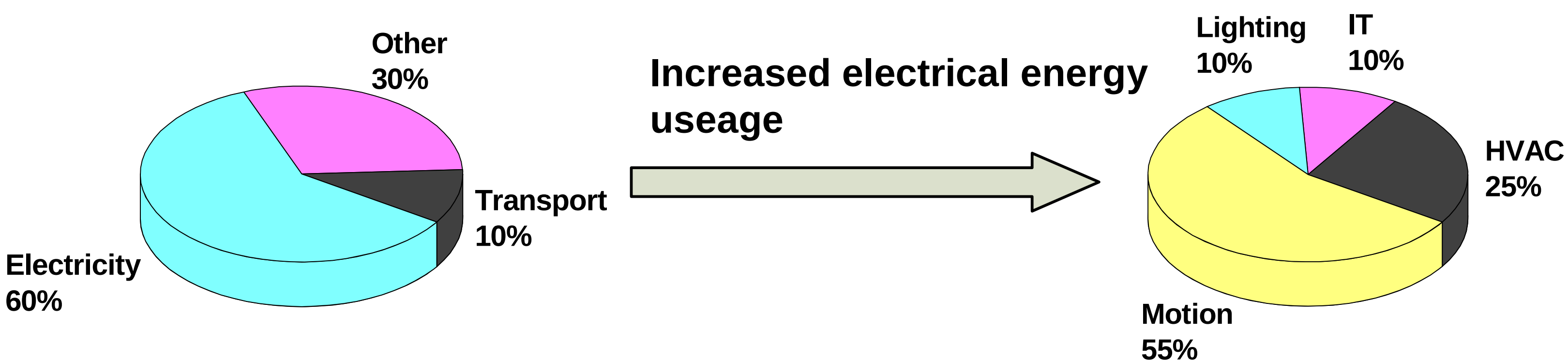


16,000 TWh/annum global electricity



The Energy Supply Chain 2040

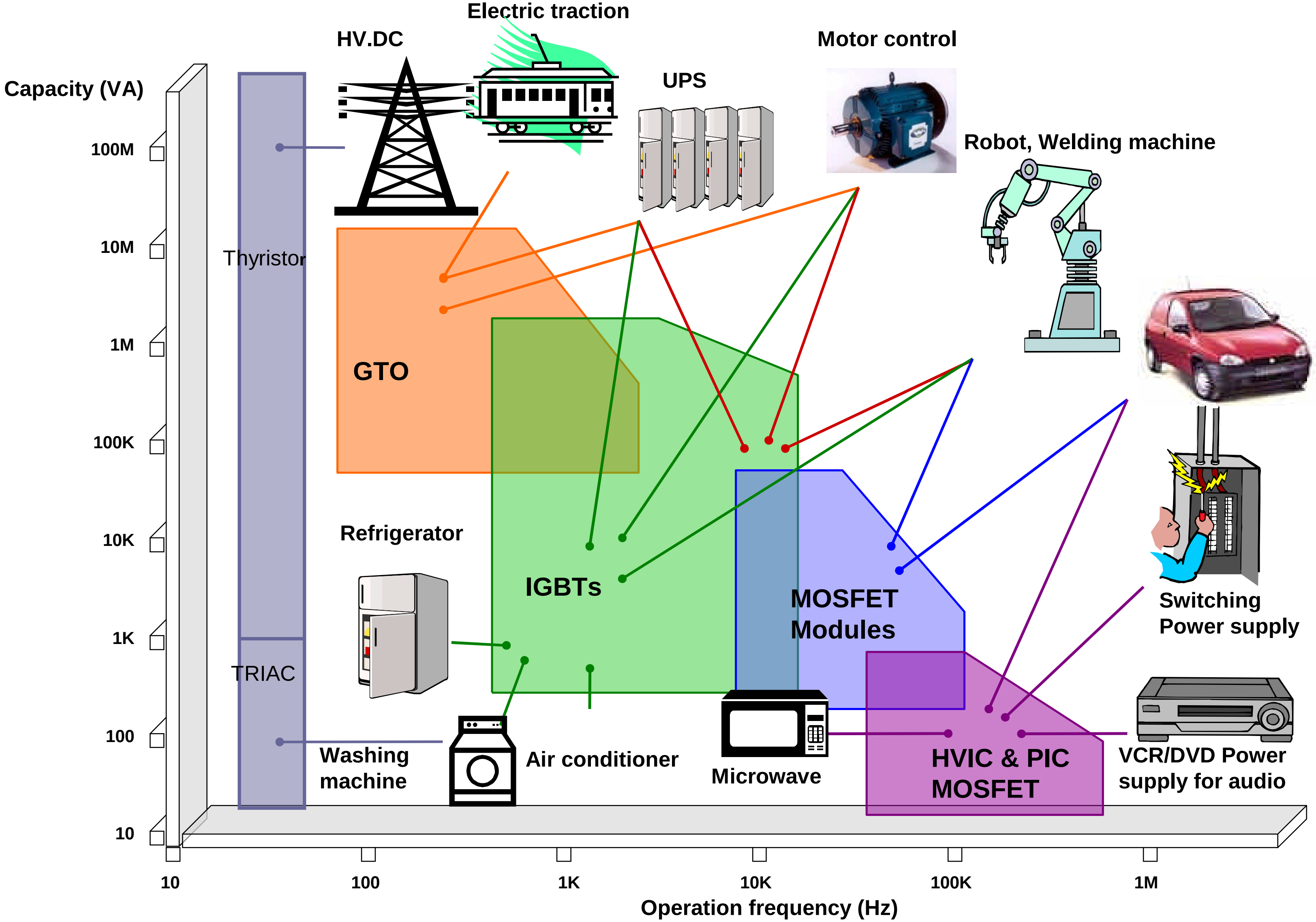




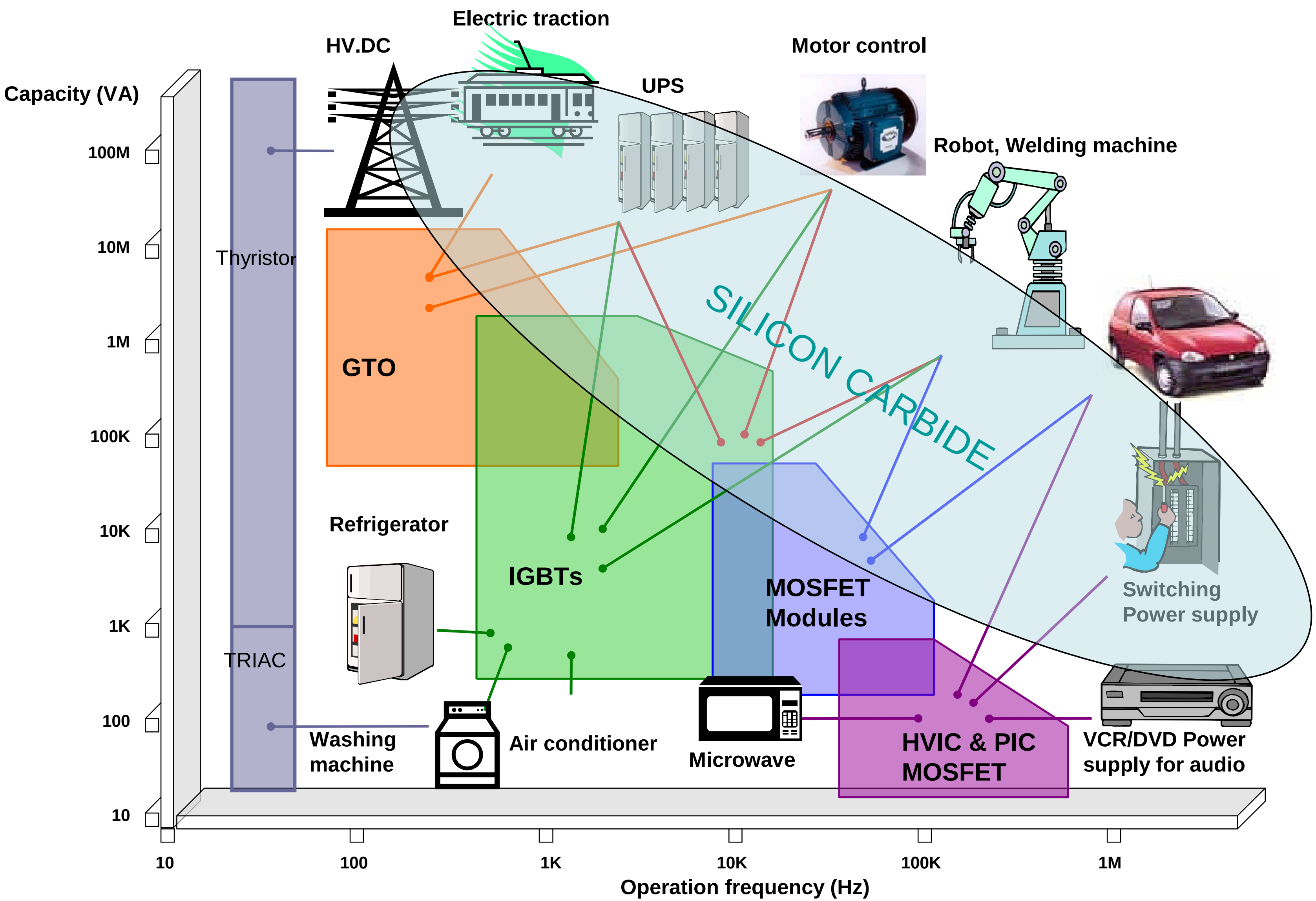
SiC Technology

Power Electronics

- Power electronics is the key enabling technology in all future sustainable energy scenarios
  - Share of electrical energy controlled by power electronics is set to increase from 40% in 2000 to 80% in 2015
- Silicon technology has reached its material limit
  - Silicon power devices are limited to temperatures less than 200 °C
  - Cannot operate silicon devices at very high frequencies
- SiC is the best wide bandgap semiconductor to replace silicon in power electronics applications
  - Excellent material properties
  - Higher technological maturity



Capacity (VA)
100M
10M
1M
100K
10K
1K
100
10
Thyristor
TRIAC
HV.DC
Electric traction
UPS
Motor control
Robot, Welding machine
GTO
IGBTs
Refrigerator
Washing machine
Air conditioner
Microwave
MOSFET Modules
Switching Power supply
HVIC & PIC MOSFET
VCR/DVD Power supply for audio
10
100
1K
10K
100K
1M
Operation frequency (Hz)



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TRIAC
GTO
IGBTs
MOSFET
Modules
HVIC & PIC
MOSFET
SILICON CARBIDE
Refrigerator
Washing
machine
Air conditioner
Microwave
Switching
Power supply
VCR/DVD Power
supply for audio
10
100
1K
10K
100K
1M
Operation frequency (Hz)


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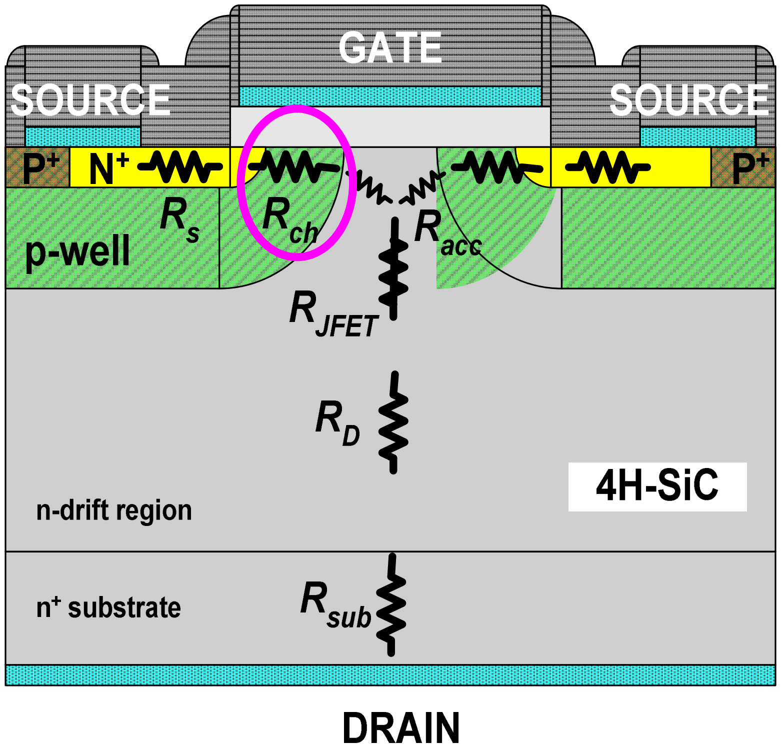
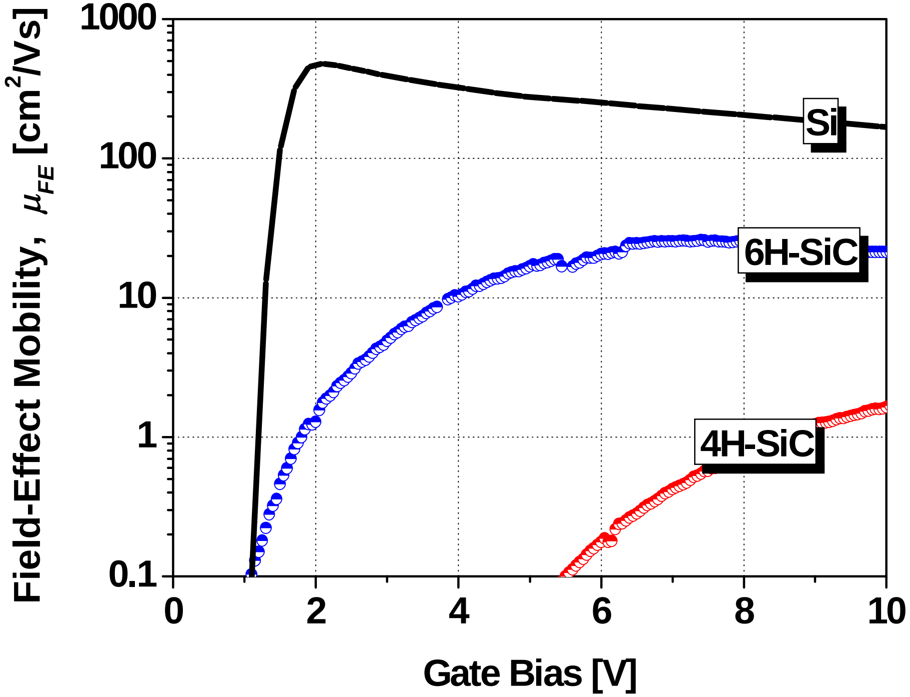
SiC Technological Problems





Surface Problems

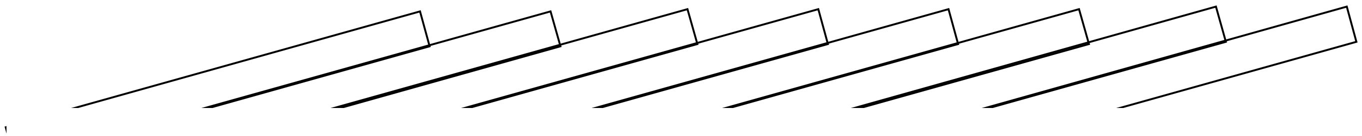


Fig.(a)

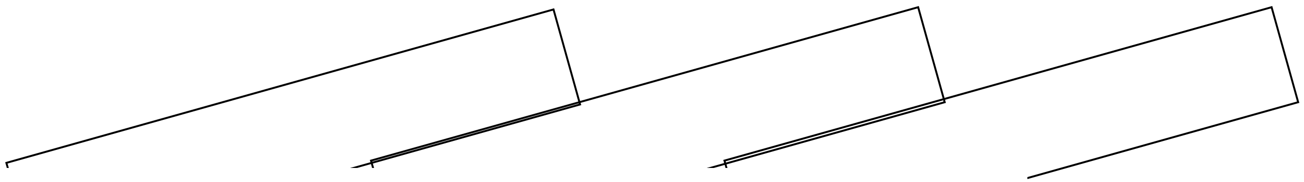
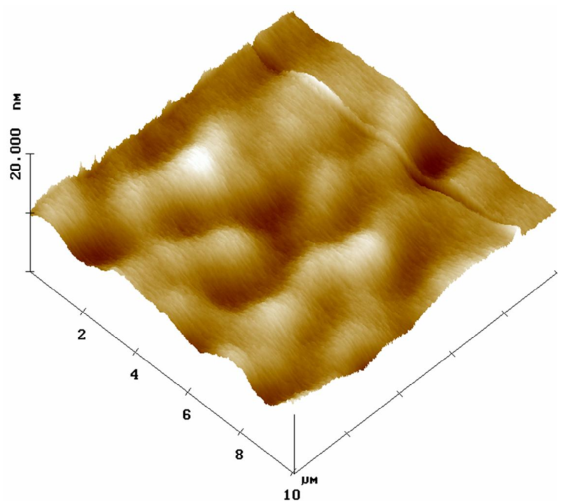
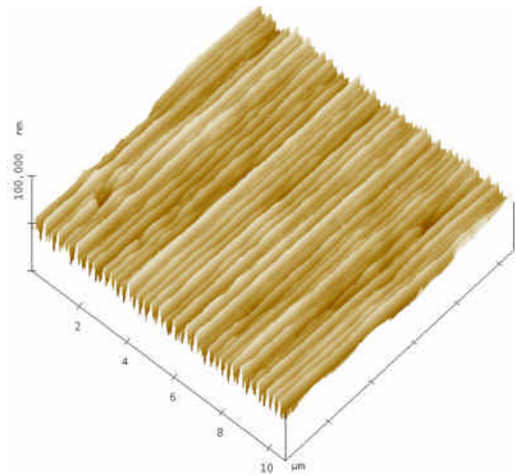


Fig.(b)

Fig. (a): Cross section illustration of 4 Si-C bi-layer as grown (b) Bunched bi-layer after annealing

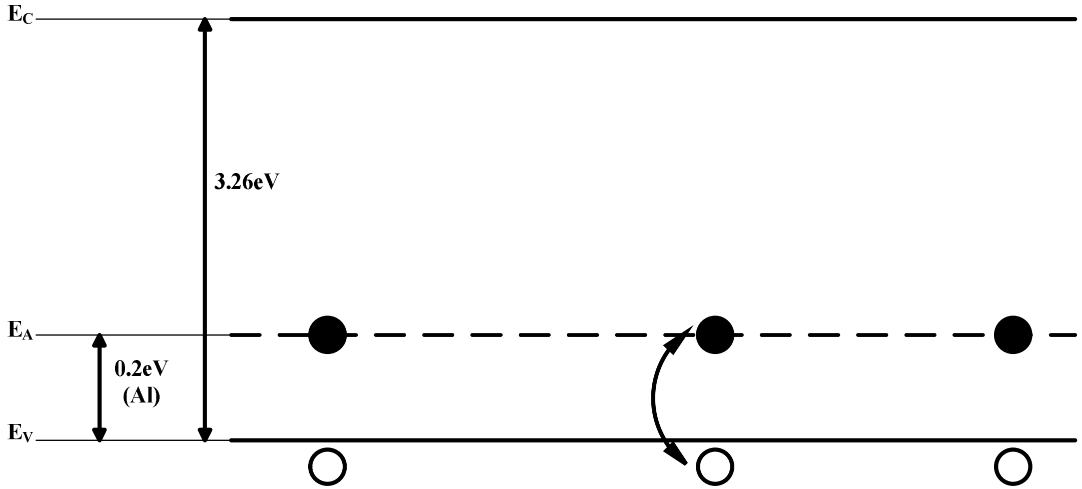


- Surface damage
- Step bunching



SiC Technological Problems

- Other remaining technological problems in 4H-SiC include:-
  - Poor dopant activation and ionisation for p-type SiC due to deep levels within the bandgap (below)
  - Shallowest p-type dopant 200 meV above valence in 4H-SiC band (Aluminium) compared to 67 meV in silicon (Boron)
  - High resistance p-type ohmic contacts (metal work function vs. semiconductor work function incompatibility)



Thank you – see poster for more info!