The end is in sight for traditional integrated electronics ...

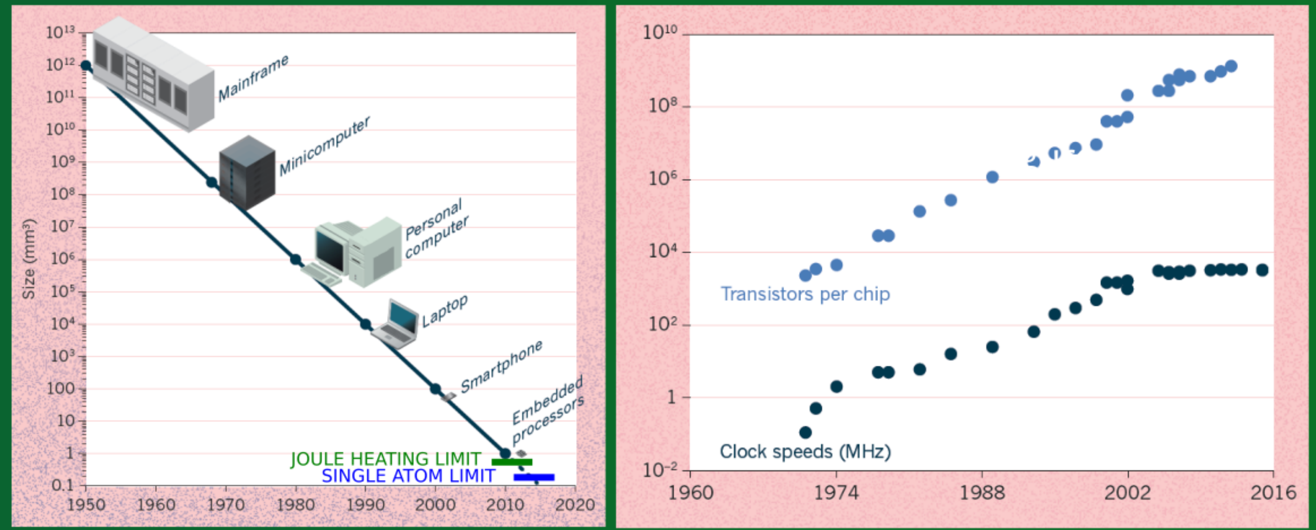


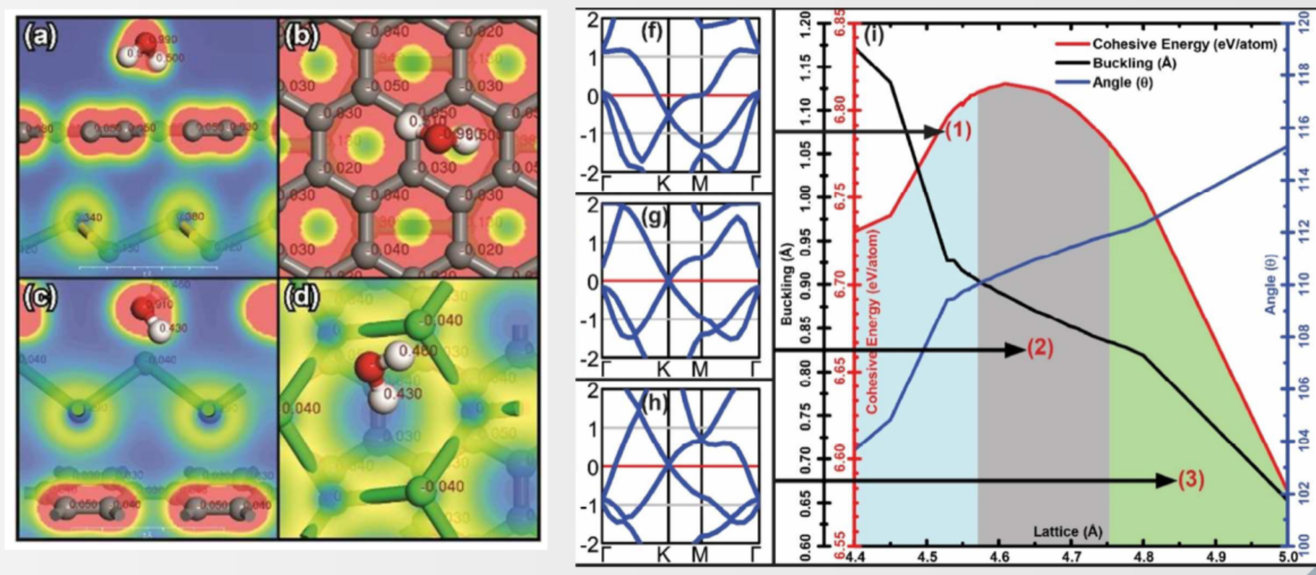
Figure adapted from "More than Moore" Nature, 530, 2016

Dissipation from electron motion in conventional semiconductors generates heat, which becomes increasingly problematic at small device dimensions. Meanwhile, with the rise of the cloud paradigm, ~ 8% of domestic power usage is now consumed by computers. The race is on to find a viable solution to both of these issues.

ARC CENTRE OF EXCELLENCE IN FUTURE LOW-ENERGY ELECTRONICS TECHNOLOGIES

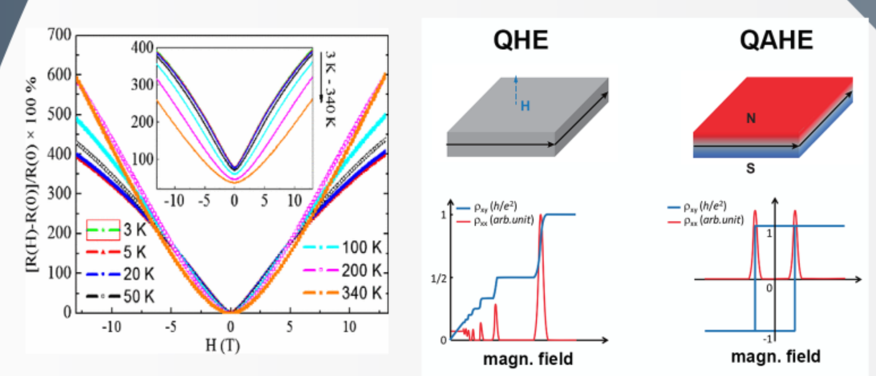
FLEET

Computer-assisted design of new materials



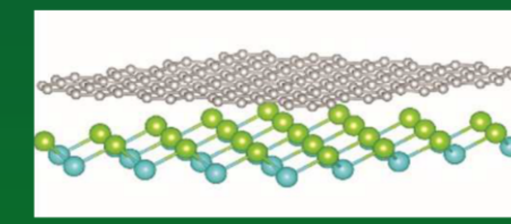
Density functional theory
Ab initio molecular dynamics

Robust quantum transport



Two dimensional and three dimensional Dirac materials

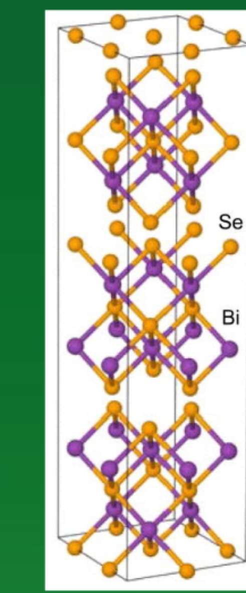
2D



Graphene
Silicene
Germanene
Stanene
Na_3Bi

3D

Bi_2Se_3
Bi_2Te
TaAs



Materials synthesis

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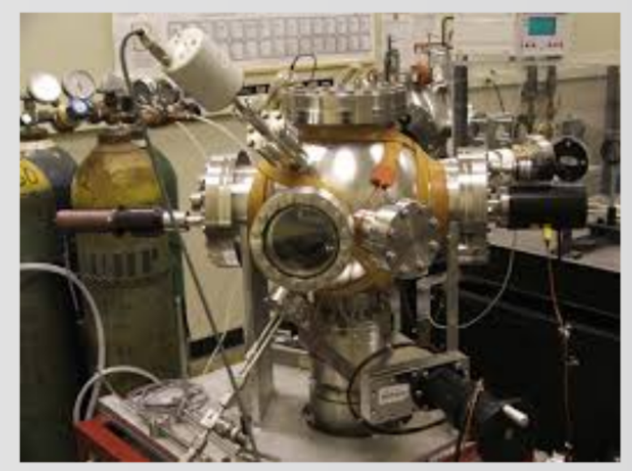
Single Crystal Growth



Pulse Laser Deposition

The Advantages of Dirac Materials

- Rapid low-loss transport is a feature of the linear (Dirac) dispersion.
- Ballistic rather than diffusive electron motion minimises Joule heating.
- Large magnetoresistance is a common feature in the high mobility 2d electron layer.
- External stimuli or gating can have a strong effect on the electronic conductivity near a Quantum Critical Point.
- For topologically-protected states, chemical defects have minimal effects on the surface conductivity.
- For 1D edge states of ultra-thin materials, transport can occur with zero disappation via Quantum Hall Effects.
- If robust magnetic order can be realized, zero-loss transport may be achievable in ambient on-chip conditions via the Quantum Anomalous Hall Effect.

Criteria for the ideal semi-metal

- Dirac dispersion with an adjustable band-gap
- Low Joule heating
- Magnetically-ordered
- Scalable: space, speed and economy
- Chemically-stable under ambient conditions
- Low dissipation charge-transport
- Environmentally-friendly

UOW and ANSTO members

Prof. Xiaolin Wang
Dr. Zhi Li
Prof. Frank Klose
Dr. David Cortie

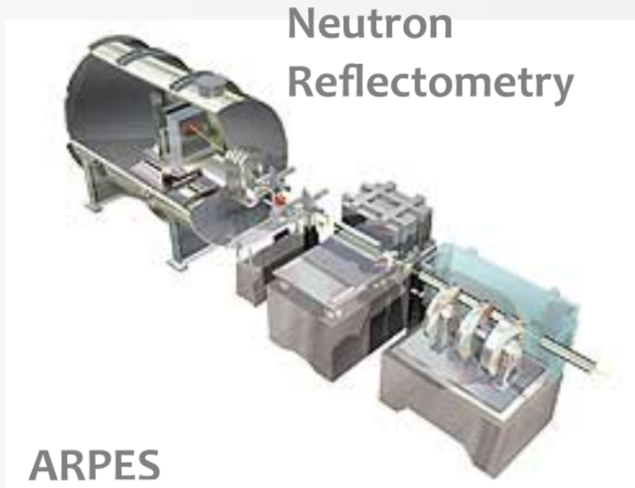
Role of the UoW Node (2017-2021)

The UoW node is involved in the broad theme of Dirac Semimetals as an enabling technology. Our team, led by Prof. Xiaolin Wang, will design and synthesise new materials in this family to realize charge and spin quantum effects. Candidates include magnetic topological insulators, Weyl semi-metals and spin-gapless semiconductors.

Nuclear toolkit for material science

Diffraction

Neutron Reflectometry

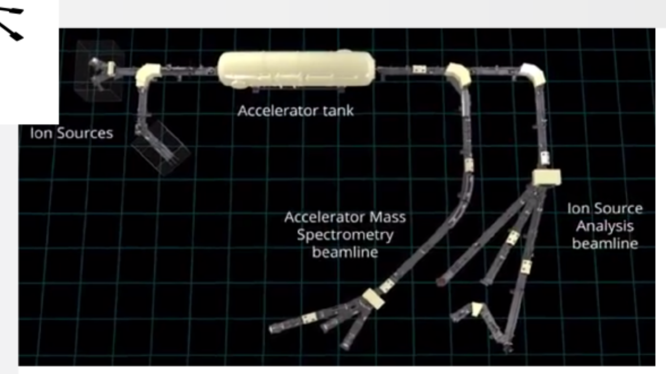


ARPES

Australian Synchrotron

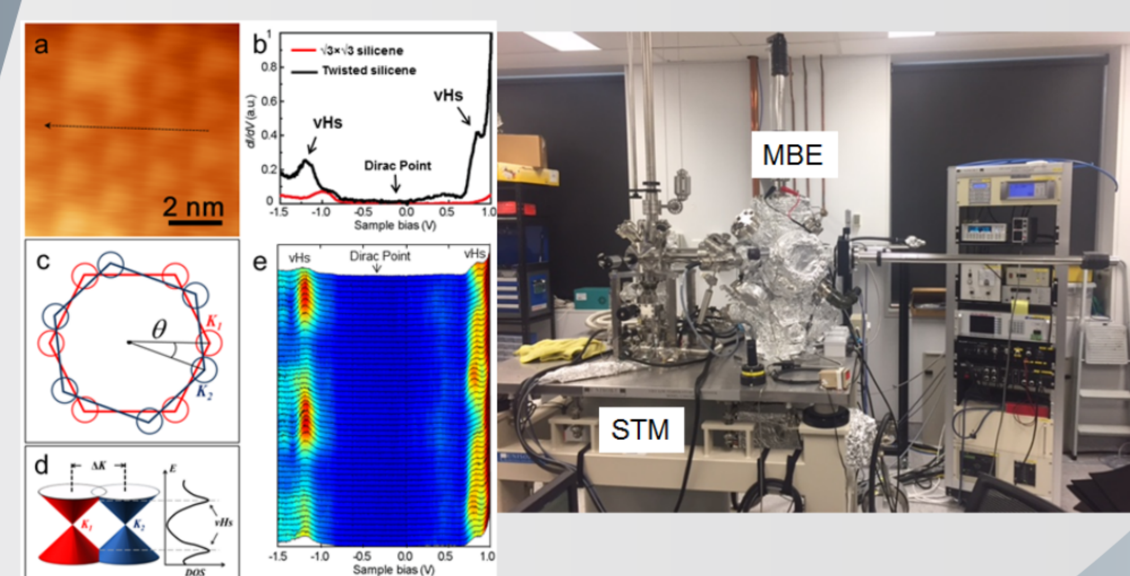
Australian Government

ansto



Ion beam modification

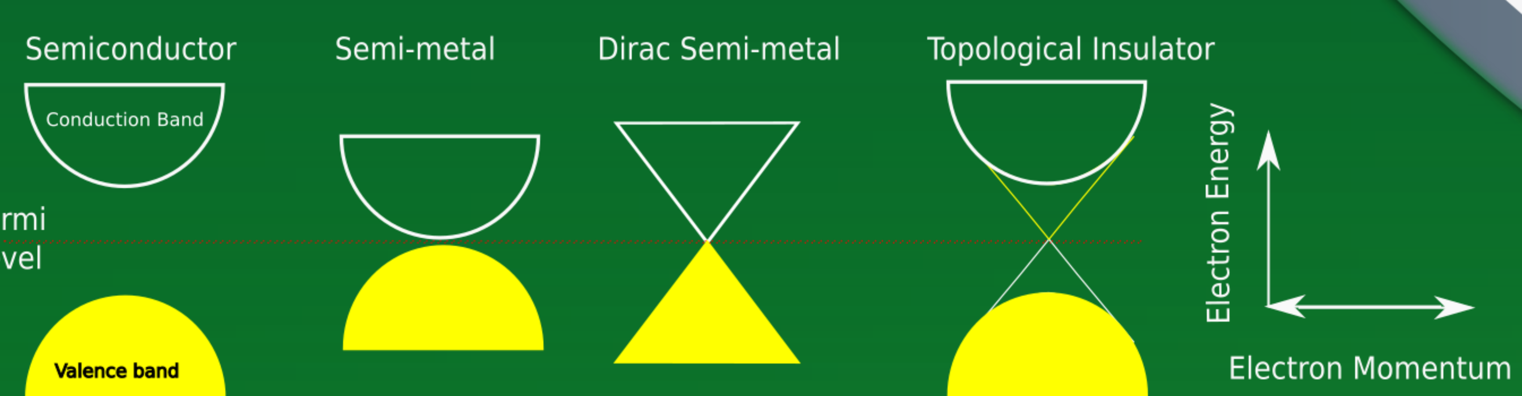
Atomic-scale characterisation



Scanning Tunneling Microscopy

Dirac semimetals

Dirac semi-metals are characterised by a linear energy dispersion with zero gap in the electronic structure. They are closely connected with the related topological insulator family, offering opportunities for zero-loss electronic transport.



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Some of our earlier related work

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[2] Cortie, Klose, Wang, Appl. Phys Lett, 101, 172404 (2012)
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[4] Zhi, Wang, ACS. Cent. Sci. , 2, 517. (2016)
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Poster template acknowlegement: Felix Breuer