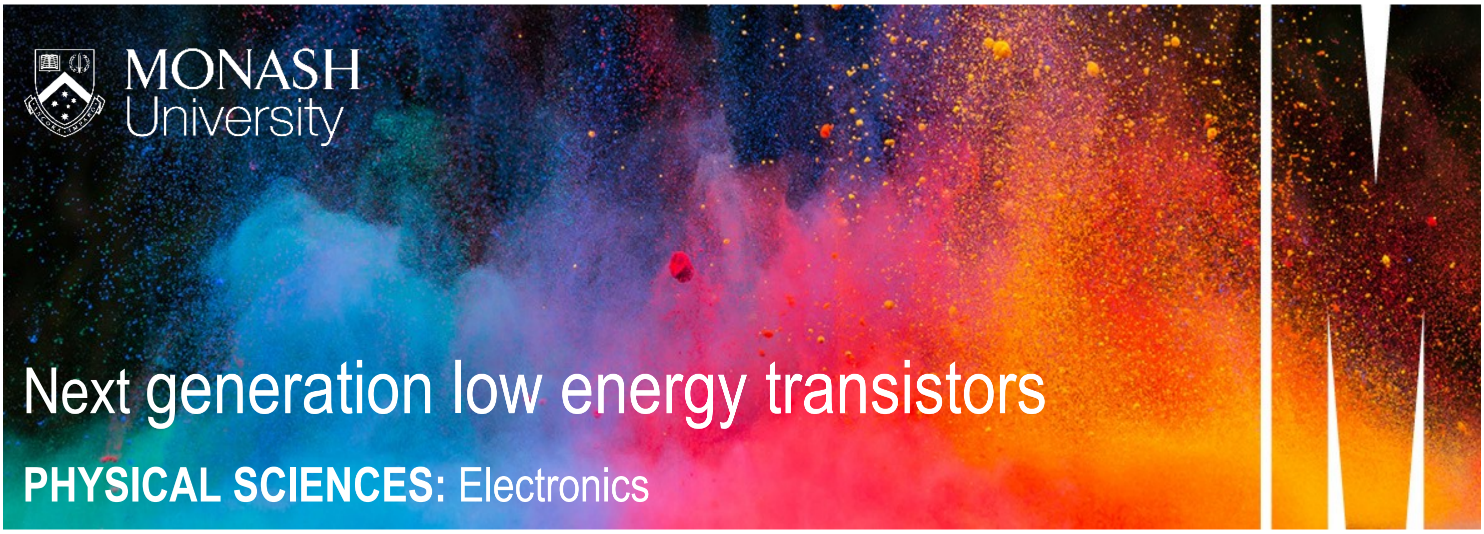
MONASH University



Next generation low energy transistors

PHYSICAL SCIENCES: Electronics

The Challenge	Energy usage for computing has been recognized by the Breakthrough Energy Fund as one of the world's major problems needing future solutions. Carbon dioxide (CO_2) emissions are linked to climate change. While energy production and chemical industries are the major CO_2 producers, large Data Centers and computing technology in general are also contributing to CO_2 emissions and energy needs; this is a fast-growing problem.
The Solution	Our solution comprises a method of forming a topological Dirac semimetal layer on a substrate. The topological transistor is switched from conventional insulator to topological insulator via an electric field, with a tuneable bandgap. The new system aims for a ten-fold improvement in energy efficiency.
Key benefits	• Novel IP on 2D materials • Demonstrated Bandgap and Switching • Awarded $34 million Australian Research Council Centre of Excellence (2017) • 14 Australian and International Science Centers
Development Stage	Technology Concept completed.
Brief Description & Differentiation	The aim for this system is a 10x improvement in energy efficiency according to Moore's Law. We envision a topological transistor in which an electric field from gate electrodes switches a material from conventional insulator to topological insulator. In the topological insulator, current will be carrier by ballistic 1D edge modes. We have developed a method of forming a topological Dirac semimetal layer on a substrate (Fig. 1). Using this 2D material we have developed an electric field-effect structure which can be used to alter the charge carrier density and band gap in a topological Dirac semimetal film. In an ultrathin topological Dirac semi-metal we can tune the bandgap by over 400 meV, from topological insulator to conventional insulator, realising a platform suitable for a topological transistor. (Fig. 2).
Research Team	Led by Prof Michael Fuhrer (ARC Laureate Fellow, Director ARC Centre of Excellence for Future Low-Energy Electronics Technologies) and Dr. Mark Edmonds (ARC DECRA Fellow)
Key Publications	J. L. Collins, et al., Nature 564 (7736), 390
Intellectual Property	National filings on PCT/AU2017/050399 (USA, China and Australia)

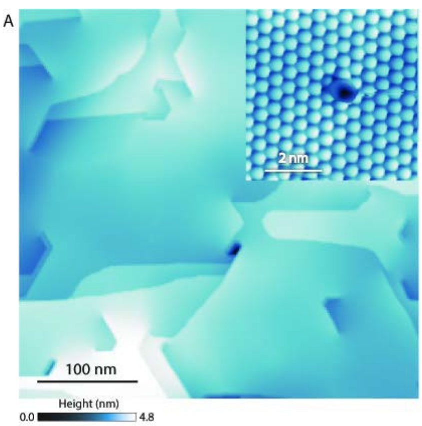


Figure 1: Epitaxial thin film of topological Dirac semimetal Na_3Bi on silicon (Image taken with scanning tunnelling microscope). Ref: M. T. Edmonds, et al., Science Advances 3 (12), eaao6661

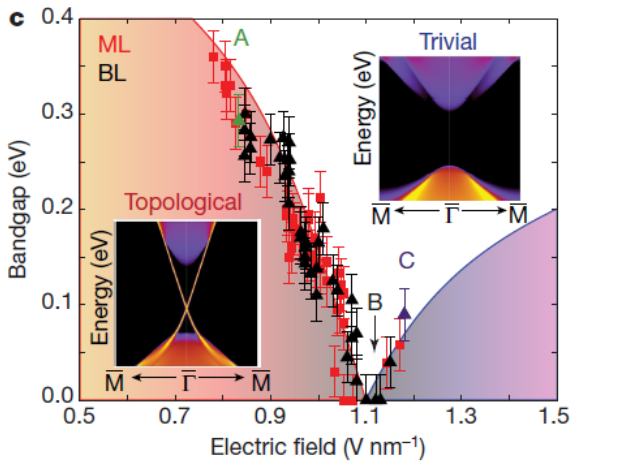


Figure 2: Tuning bandgap of ultrathin Na_3Bi with electric field. Ref: J. L. Collins, et al., Nature 564 (7736), 390