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 (CO₂) emissions are linked to climate change. While energy production and chemical industries are the major CO₂ producers, large Data Centers and computing technology in general are also contributing to CO₂ 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 Na₃Bi on silicon (Image taken with scanning tunnelling microscope). Ref: M. T. Edmonds, et al., Science Advances 3 (12), eaa06661

Figure 2: Tuning bandgap of ultrathin Na₃Bi with electric field. Ref: J. L. Collins, et al., Nature 564 (7736), 390