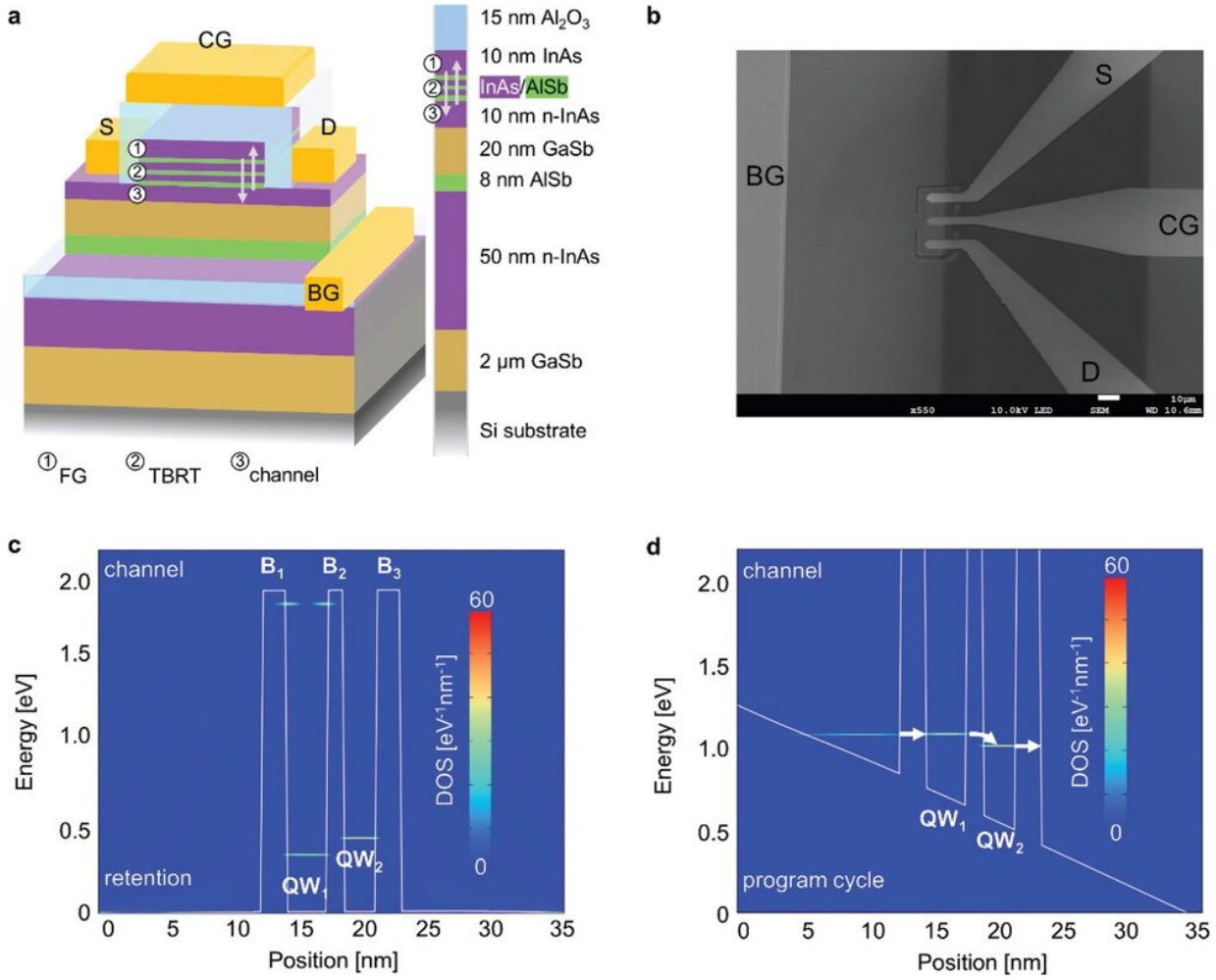
Novel memory technology based on compound semiconductors

January 7 2022



ULTRARAM device concept. a) Schematic cross-section of a device with corresponding material layers. The floating gate (FG), triple-barrier resonant-tunneling structure (TBRT), and readout channel are highlighted. Arrows indicate the direction of electron flow during program/erase operations. b)

Scanning electron micrograph of a fabricated device of 10 µm gate length. c,d) Nonequilibrium Green's functions (NEGF) calculations of density of states alongside conduction band diagrams for no applied bias (i.e., retention) and program-cycle bias respectively. B1, B2, and B3 are the AlSb barrier layers. QW1 and QW2 are the InAs quantum wells in the TBRT. Credit: DOI: 10.1002/aelm.202101103

A pioneering type of patented computer memory known as ULTRARAM has been demonstrated on silicon wafers in what is a major step towards its large-scale manufacture.

ULTRARAM is a novel type of memory with extraordinary properties. It combines the non-volatility of a data storage memory, like flash, with the speed, energy-efficiency and endurance of a working memory, like DRAM. To do this it utilizes the unique properties of compound semiconductors, commonly used in photonic devices such as LEDS, laser diodes and infrared detectors, but not in digital electronics, which is the preserve of silicon.

Initially patented in the US, further patents on the technology are currently being progressed in key technology markets around the world.

Now, in a collaboration between the Physics and Engineering Departments at Lancaster University and the Department of Physics at Warwick, ULTRARAM has been implemented on silicon wafers for the very first time.

Professor Manus Hayne of the Department of Physics at Lancaster, who leads the work said, "ULTRARAM on silicon is a huge advance for our research, overcoming very significant materials challenges of large crystalline lattice mismatch, the change from elemental to compound

semiconductor and differences in thermal contraction."

Digital electronics, which is the core of all gadgetry from smart watches and smart phones through to personal computers and datacentres, uses processor and memory chips made from the semiconductor element silicon.

Due to the maturity of the silicon chip-making industry and the multi-billion dollar cost of building chip factories, implementation of any digital electronic technology on silicon wafers is essential for its commercialisation.

Remarkably, the ULTRARAM on silicon devices actually outperform previous incarnations of the technology on GaAs compound semiconductor wafers, demonstrating (extrapolated) data storage times of at least 1000 years, fast switching speed (for device size) and program-erase cycling endurance of at least 10 million, which is one hundred to one thousand times better than flash.

The research is reported in the journal *Advanced Electronic Materials.*

More information: Peter D. Hodgson et al, ULTRARAM: A Low-Energy, High-Endurance, Compound-Semiconductor Memory on Silicon, *Advanced Electronic Materials* (2022). DOI: 10.1002/aelm.202101103

Provided by Lancaster University