# AUTOMATED MANUFACTURE OF SEMICONDUCTORS USING NANOMATERIALS

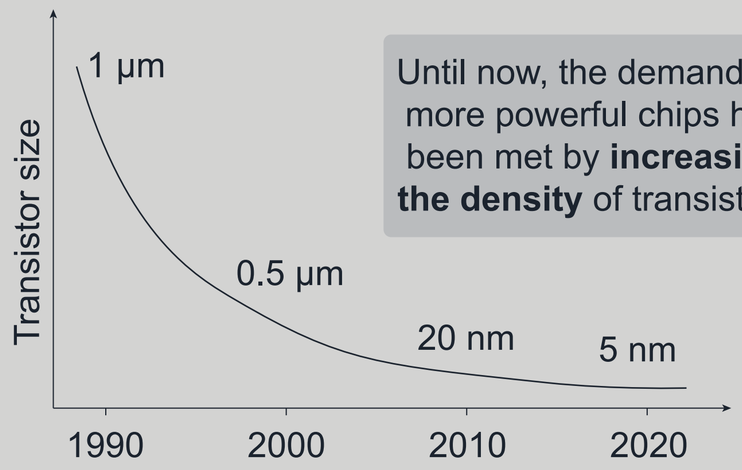
Teja Potocnik[1], Peter J. Christopher[1], Ralf Mouthaan[1], Charlotte V. Esler[2], Fletcher J. Young, Jack Alexander-Webber[1]

[1]Department of Engineering, University of Cambridge, 9 JJ Thompson Avenue, Cambridge, CB3 0FA

[2]Judge Business School, University of Cambridge, Trumpington St, Cambridge CB2 1AG

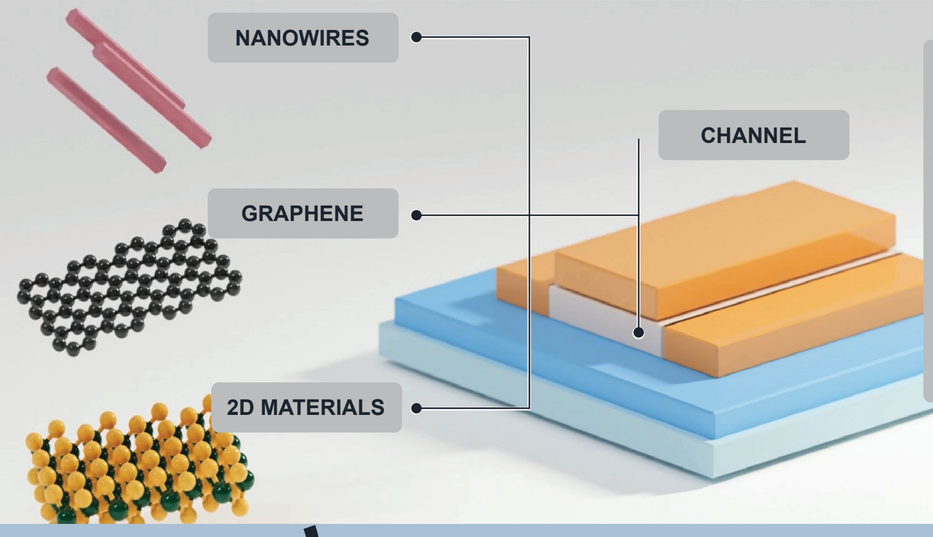
## THE NANOMATERIAL SCALABILITY CHALLENGE

### TRANSISTORS CANNOT GET ANY SMALLER




Until now, the demand for more powerful chips has been met by **increasing the density** of transistors

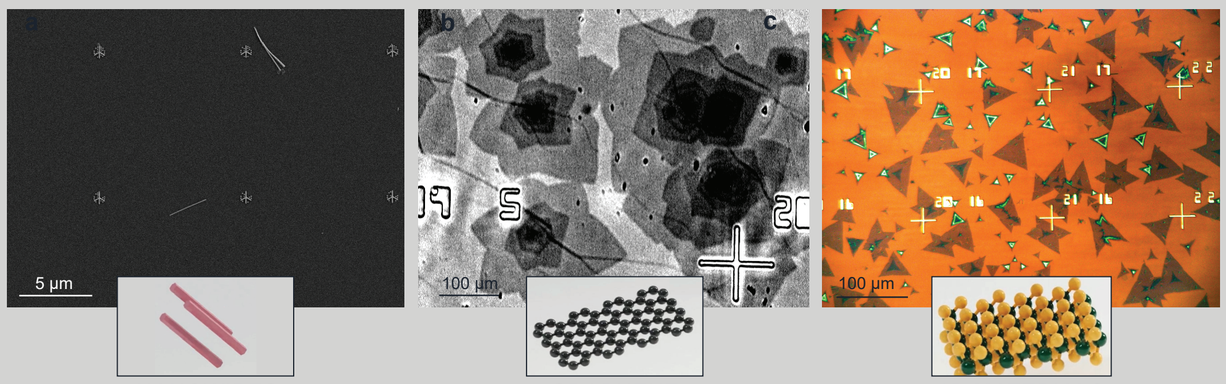
### NANOMATERIALS ARE THE SOLUTION




- **1000x smaller** than a human hair
- **200x faster** than conventional electronics
- Increase chip power while maintaining size

### INDUSTRY CURRENTLY CANNOT USE NANOMATERIALS

- Grown nanomaterials are **randomly distributed** on substrates
- Finding them is **manually-intensive** and **time-consuming**
- Currently **unscalable** for industrial manufacturing




## OUR SOLUTION: AN AUTOMATED LOCATION SYSTEM FOR NANOMATERIALS

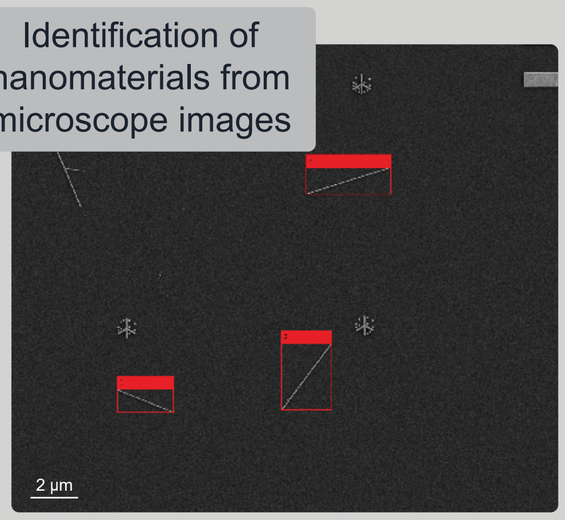
### STAGE 1: LITHOTAG™ MARKER

- Novel coordinate system for locating nanomaterials
- Reproducible at nanoscales


Nanowires on silicon with LithoTags™

### STAGE 2: COMPUTER-VISION

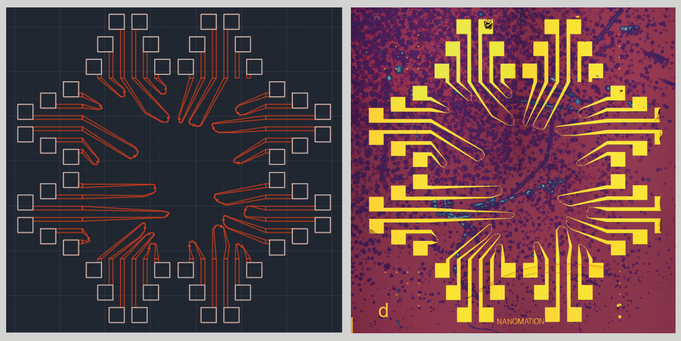
Identification of nanomaterials from microscope images




Nanowires identified with computer vision

### STAGE 3: CIRCUIT ROUTING

Automated manufacturing of circuits around identified nanomaterials

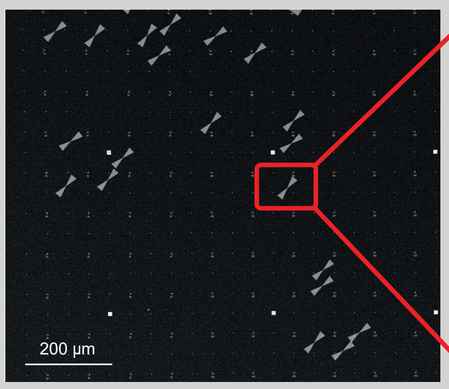


Circuit design in computer software

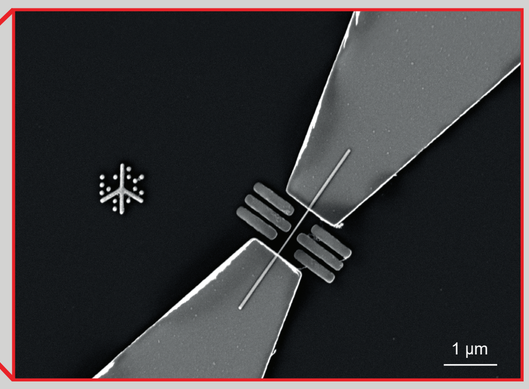
Manufactured circuit with gold electrodes

### AUTOMATED FABRICATION OF NANOWIRE TRANSISTORS

Using our method we **automatically manufactured** over 200 nanowire transistors (Potocnik et al. ACS Nano. 2022)




Nanowire transistors dispered on silicon with LithoTag™ array

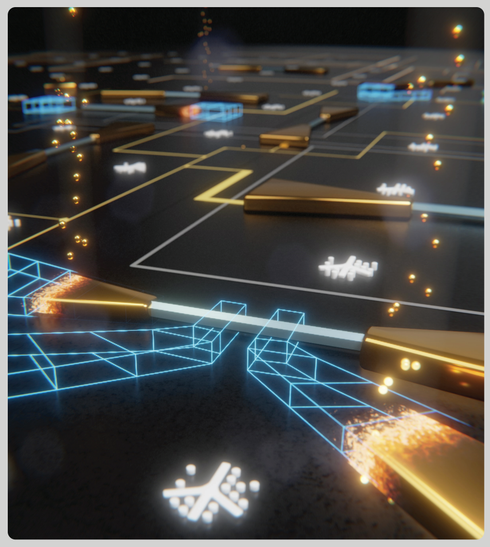



Nanowire transistor with associated LithoTag™

### NANOMATERIAL-BASED CHIPS IN EVERYDAY ELECTRONICS

- **12,000x faster** manufacture of nanomaterial-based chips
- Unlocks use of **nanomaterials** in **commercial electronics**

- Nanomaterial-based chips use **less energy**
- Reducing dependence on **rare earths** increases the resilience of the semiconductor supply chain



Automated manufacturing with LithoTags™