UCR Department of Electrical and Computer Engineering: Overview

Ertem Tuncel

UC RIVERSIDE
Electrical and Computer Engineering

ECE@UCR: Administrative Structure

Electrical and Computer Engineering (ECE)

Chair
Ertem Tuncel

Vice-Chair
Roger Lake

CEN Director
Hyoseung Kim

Graduate Advisor
Daniel Wong

Undergrad Advisor
Allan Knight

Graduate Advisor
Nanpeng Yu

Undergrad Advisor
Roman Chomko

Department Manager
Nicole Kramer

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ECE@UCR: At a Glance

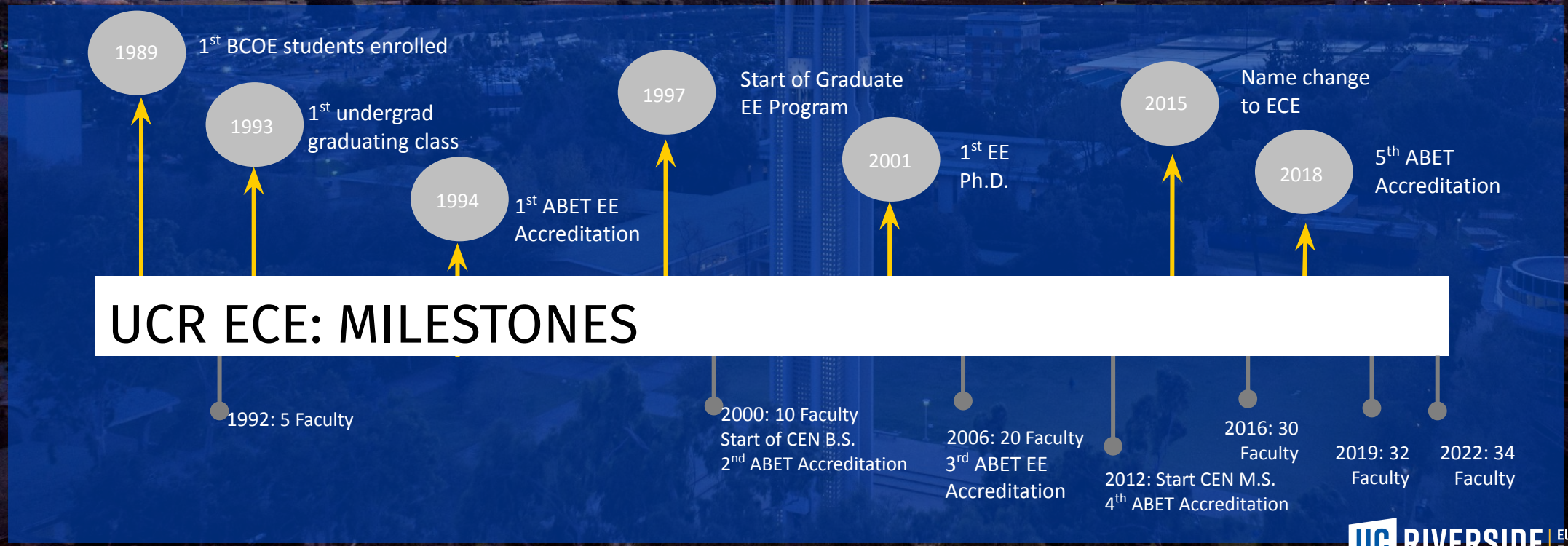
$14.2M+
Research Grants in FY20-21 and FY21-22 combined

#38
US News 2022 Best Public University

34
Faculty Members

200+
Graduate Students

400+
Undergraduate Students



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ECE Faculty

ECE Honors, Awards, and Leadership

FELLOWS

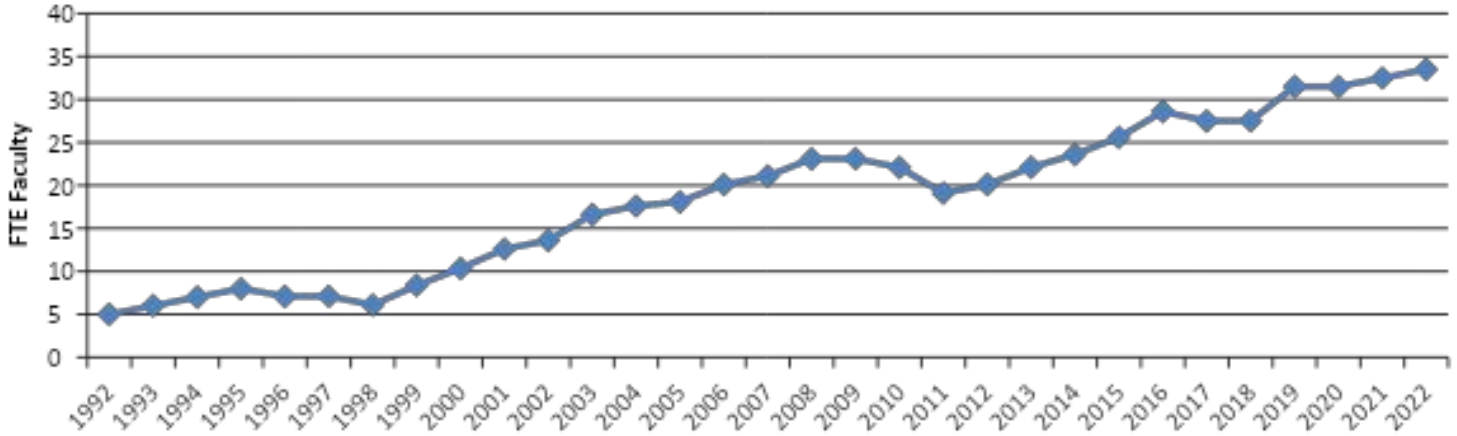
IEEE: 12
AAAS: 6
SPIE/IAPR: 4
IOP/IFAC/MRS/OSA: 4
NAI: 3

IEEE SOCIETY PRESIDENTS

EDS 2014 - 2015
CSS 2014
ITS 2014 – 2015
AACC 2020 – 2021

RESEARCH INITIATION

NSF Career: 17
ARO YIA: 2
ONR YIP: 1



34 Faculty, 1 new:
- Cong Liu

Faculty organized into 3 broad themes
- **Signals, Systems and Machine Intelligence**: Communications and Signal Processing, Control and Robotics, Intelligent Systems, Power and Smart Grid
- **Computer Engineering**
- **Nano Materials and Devices**

Undergraduate Education

Focus Areas

- Communications, Signal Processing, and Networking
- Control and Robotics
- Embedded Systems and VLSI
- Intelligent Systems
- Nanotechnology, Advanced Materials, and Devices
- Power Systems and Smart Grid

Technical electives must include at least one coherent sequence of at least 4 courses (2 required courses + 2 additional) in 1 focus area of electrical engineering

Communications, Signal Processing, and Networking (CSPN)

EE 115 - Required	Intro to Communications (4)
EE 141 - Required	Digital Signal Processing (4)
EE 100B	Electronic Circuits II (4)
EE 117	Electromagnetics II (4)
EE 118	Radio Frequency Circuit Design (4)
EE 146	Computer Vision (4)
EE 150	Digital Communications (4)
EE 152	Image Processing (4)
ENGR 160	Intro Engr. Optimizatn. Techniqs. (4)

Control and Robotics (CR)

EE 105 – Required	Modeling & Simulation of Dynamic Sys (4)
EE 144 - Required	Introduction to Robotics (4)
EE 106	Programming Practical Robots (4)
EE 141	Digital Signal Processing (4)
EE/ME 145	Robotic Planning & Kinematics (4)
EE 146	Computer Vision (4)
EE 151	Intro to Digital Control (4)
EE 152	Image Processing (4)
ENGR 160	Intro Engr. Optimizatn. Techniqs. (4)

Embedded Systems and VLSI

EE 128 – Required	Sens. & Act. for Embedded Syst. (4)
EE/CS 168 - Required	Introduction to VLSI Design (4)
EE 100B	Electronic Circuits II (4)
EE 117	Electromagnetics II (4)
EE 118	Radio Frequency Circuit Design (4)
EE 135	Analog Integrated Circuit Layout and Design (4)
EE 141	Digital Signal Procesing (4)
EE 147	GPU Computing and Programming (4)
EE 165	Des. for Reliab. of Integ. Circuits and Sys. (4)
CS 161	Des. and Architecture of Computer Systems (4)
CS 162	Computer Architecture (4)

Intelligent Systems (IS)

EE 144 – Required	Introduction to Robotics (4)
EE 146 - Required	Computer Vision (4)
EE 105	Modeling & Simulation of Dynamic Sys (4)
EE 106	Programming Practical Robots (4)
EE 115	Intro to Communications (4)
EE 128	Sensing and Actuation for Embed. Sys. (4)
EE 141	Digital Signal Procesing (4)
EE/ME 145	Robotic Planning & Kinematics (4)
EE 147	GPU Computing and Programming (4)
EE 150	Digital Communications (4)
EE 151	Introduction to Digital Control (4)
EE 152	Image Processing (4)
ENGR 160	Intro to Engineering Optimization Techniques (4)

Nanotechnology, Advanced Materials, and Devices (NMD)

EE 136 – Required	Semiconductor Device Processing (4)
EE 137 - Required	Intro to Semiconductor Opto. Dev. (4)
EE 100B	Electronic Circuits II (4)
EE 117	Electromagnetics II (4)
EE 118	Radio Frequency Circuit Design (4)
EE 135	Analog Integ. Circuit Layout and Design (4)
EE 138	Electronic Properties of Materials (4)
EE 139	Magnetic Materials (4)
EE 162	Intro to Nanoelectronics (4)
EE/CS 168	Introduction to VLSI Design (4)

Power Systems and Smart Grid

EE 123 - Required	Power Electronics (4)
EE 155 - Required	Power System Analysis (4)
EE 100B	Electronic Circuits II (4)
EE 117	Electromagnetics II (4)
EE 128	Sensing and Actuation for Embed. Sys. (4)
EE 153	Electric Drives (4)
ENGR 160	Intro to Engr. Optimization Techniques (4)

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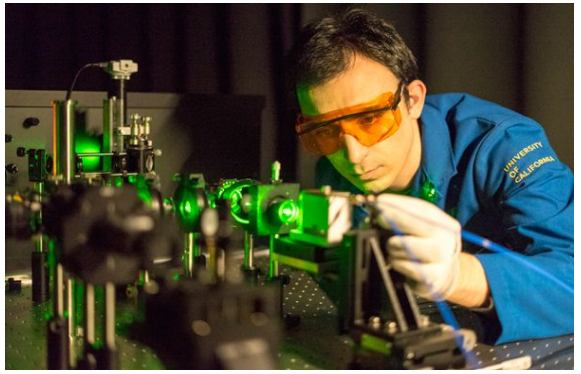
ECE Research Area

Nanotechnology, Advanced Materials & Devices

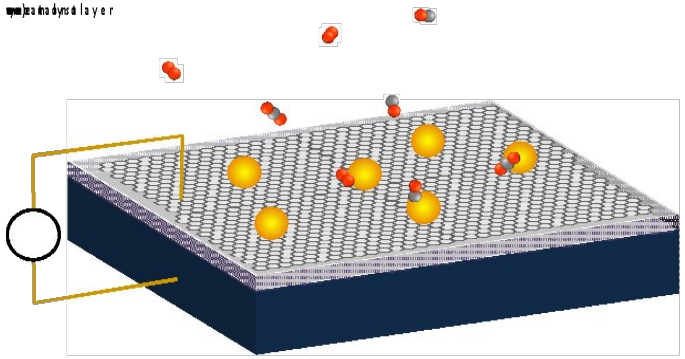
- Theoretical computational and experimental investigation of nanoscale materials and devices
- Development of novel electronic, optoelectronic, photonic, bio-medical devices and circuits
- Advanced materials and device technologies for renewable energy application



Nano Device Laboratory, Alexander Balandin

Sample Projects

- Data driven discovery of synthesis pathways and distinguishing electronic phenomena
- Magnonic Active Ring Memory and Logic
- Development of a Cryogenic Integrated Micro-Raman-Brillouin-Mandelstam Spectrometer



Nano-Optoelectronics Lab, Ming Liu

AAA-Battery Laboratory, Mihri Ozkan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ECE Research Area
Computer Engineering

- Design and implementation of hardware and software systems
- Computer architecture, VLSI design, real-time and embedded systems
- Networked systems from small scale (e.g., Internet of Things) to large scale (e.g. data centers)

MSLAB, Sheldon Tan

Sample Projects

- Machine Learning Approach for Fast Electromigration Analysis and Full-Chip Assessment
- Real-time Energy-elastic GPUs for Embedded Autonomous Systems
- Model-based Software Synthesis for Cyber-Physical Systems

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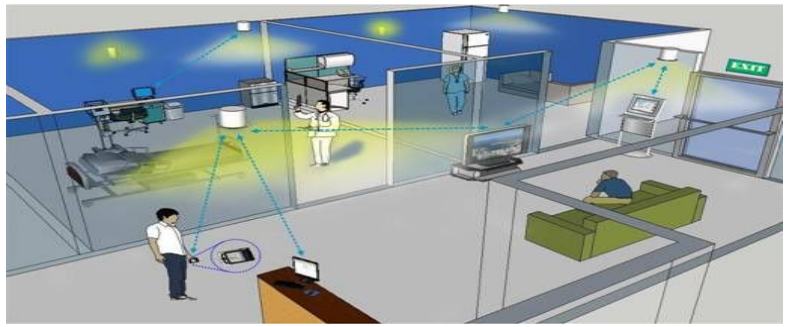

UC-Light, Albert Wang

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ECE Research

Facilities & Research Centers

Autonomous Robots and Controls Systems (ARCS) Lab
Fundamental robotics research enabling robust, adaptive, and resilient planning and control of teams of legged and aerial robots in dynamic and uncertain environments.
Director: Kostas Karydis

Center for Environmental Research & Technology (CE-CERT)
CE-CERT is a world-leading research center focused on improving air quality, transportation, and energy for a sustainable future.
Director: Don Collins

Center for Nanoscale Science & Engineering Nano-Fabrication Facility (CNSE)
Class 100/1000 cleanroom facility, fully equipped for advanced nanofabrication and characterization.
Director: Shane Cybart

Center for Networked Configurable Command, Control and Communications for Rapid Situational Awareness (NC4)
Will develop secure, fully networked command, control and communications infrastructure to enable integrated and optimal decision-making. Creating a more resilient and sustainable electricity grid using next-generation materials.
Co-Directors: Amit Roy-Chowdhury and Srikanth Krishnamurthy

Center for Robotics and Intelligent Systems (CRIS)
Conducts cutting-edge research on the foundations and applications of intelligent and autonomous systems, including robotics, computer vision, machine learning, real-time systems, and biomedical systems, among others.
Director: Amit Roy-Chowdhury

Center for Ubiquitous Communication by Light (UC-Light)
UC-light is a UC system-wide research program focused on developing LED-based optical wireless communications technologies and systems.
Director: Albert Wang

PHONON OPTIMIZED ENGINEERING MATERIALS (POEM)
Materials characterization research focused on phonon and thermal properties of advanced materials.
Director: Alexander Balandin

Ultra Materials for a Resilient, Smart Electricity Grid (Ultra EFRC, ASU) (A. Balandin and R. Wilson @ UCR)
Creating a more resilient and sustainable electricity grid using next-generation materials. (Focus on wide bandgap semiconductors)

WINSTON CHUNG GLOBAL ENERGY CENTER (WCGEC)
Renewable energy center focused on developing emerging energy solutions related to storage, generation and distribution.
Director: Reza Abbaschian

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University of California Riverside
Center for Nano Science and Engineering

Professor Shane Cybart Director
Department of Electrical Engineering
Materials Science Engineering Program
University of California Riverside

September 21, 2022

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Center for Nano Science and Engineering (CNSE)

Nanofabrication Facility (Nanofab)

General use 8000 square foot cleanroom recharge facility.

Ion Beam Lab (IBL)

Focused and broad beam ion sources for nanofabrication and materials modification

Oxide Thin Film Lab

Future expansion

Shared pulsed laser deposition laboratory for epitaxial thin film growth.

CNSE Staff

Shane Cybart, Director

Nicole Kramer, Financial & Administrative Officer

Dong Yan, Cleanroom Manager

Ilkuen Lee, Academic Coordinator

Nadine Okuns, Fund Manager

Eva Barriga, Administrative Assistant

Nanofabrication Research at CNSE

- 1D and 2D materials
- Phononics
- Superconducting Quantum Electronics
- Medical Devices
- Energy Materials

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NANOFABRICATION FACILITY

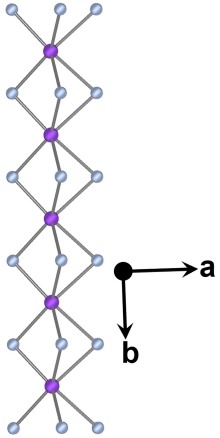
FABRICATION PROCESSES

Standard suite of capabilities available in clean room operations: Surface preparation, Thermal gate oxidation, Low Pressure and Plasma Enhanced Chemical Vapor Deposition, Photolithography and associated wet chemical processing, Electron-beam Pattern Generation, Reactive Ion Etching, Plasma Etching, Atomic Layer Deposition, Thermal and Electron-beam Evaporation of various metals and materials, Metal Sputtering and Rapid Thermal Annealing.

METROLOGY CAPABILITIES

Metrology tools with material and surface analysis capability includes: Oxide metrology for oxide/nitride measurements, Atomic Force Microscopy (AFM), Energy dispersive Spectroscopy (EDS), Electron Backscatter Diffraction (EBSD), Scanning Transmission Electron Microscopy (STEM), Thin-film profiling for photo resist and metal layer thickness, C/V Stress measurement to ensure gate oxide process integrity, I/V Probe for electrical parametric control, Digital camera display optical and Confocal Microscopes for surface inspection and 3D surface analysis.

Balandin Group – Phonon Optimized Engineered Materials (POEM) Center



Alexander A. Balandin
Founding Chair – UCR MSE Program

The MRS Medal for discovery of unique heat conduction properties of graphene

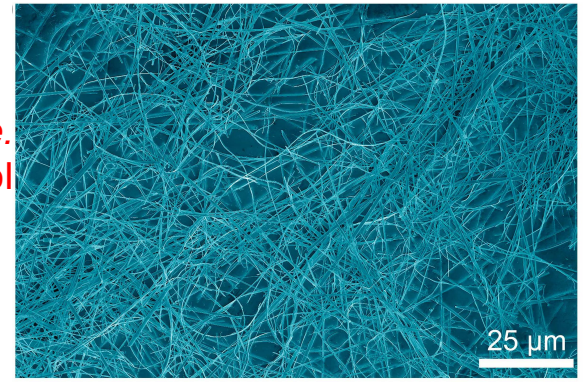
IEEE Pioneer of Nanotechnology Award for nanoscale phonon engineering

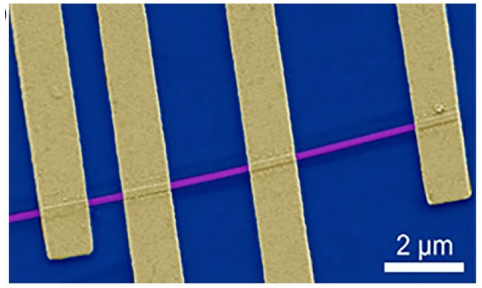
Vannevar Bush Faculty Fellowship for 1D quantum materials with $3M funding

Fellow of MRS, APS, IEEE, SPIE, OSA

Google Scholar h-index = 100

Mechanical and chemical exfoliation of chemical-vapor-transport synthesized vdW materials, *e.* $TaSe_3$, $ZrTe_3$, NbS_3, TaS_2, MoI and other TMTs and TMDs



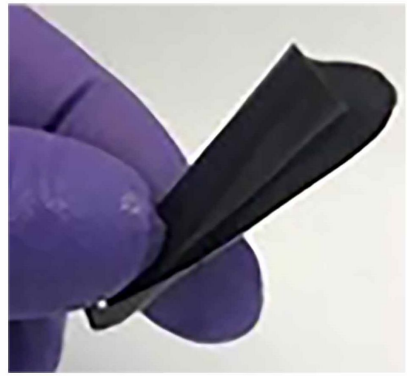


Nanofabrication of individual devices by EBL and shadow mask

Ink-jet printing and solution processing of bulk devices

A. A. Balandin, et al., “One-dimensional van der Waals quantum materials", Mater. Today, 55, 74-91 (2022).

Synthesis and characterization of bulk composites with 1D and 2D vdW fillers



Nanofab Future Roadmap

UCR Nanofab is in the process of moving to a new 8000 sq ft class 100 facility

Our campus has recently committed $2.5 million for Nanofab equipment

Heidelberg DW66 direct write laser lithography system
- 300 nm 8” i-line process
- backside alignment

Temescal electron e-beam evaporator
- BJD-2000
- 8 pocket 6kw gun
- argon ion mill

Raith SEM-electron beam lithography
- 30kV Thermo-Fisher SEM w/ Raith Elphy

Karl Suss automated coater and developer station
- I-line photoresist and PMMA

Ellipsometer, profilometer and optical microscopes

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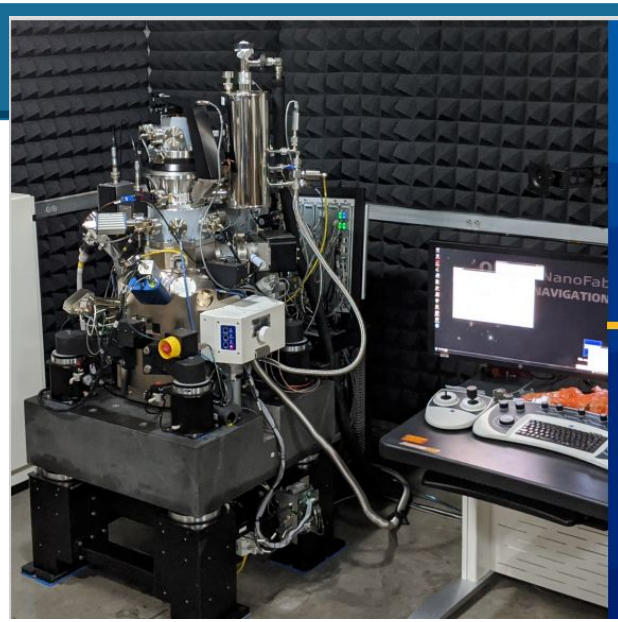


CENTER FOR NANOSCALE SCIENCE AND ENGINEERING-ION BEAM LAB

LABORATORY SPECIALIZING IN DEVICE FABRICATION AND CHARACTERIZATION UTILIZING FOCUSED AND BROAD BEAM ION SOURCES

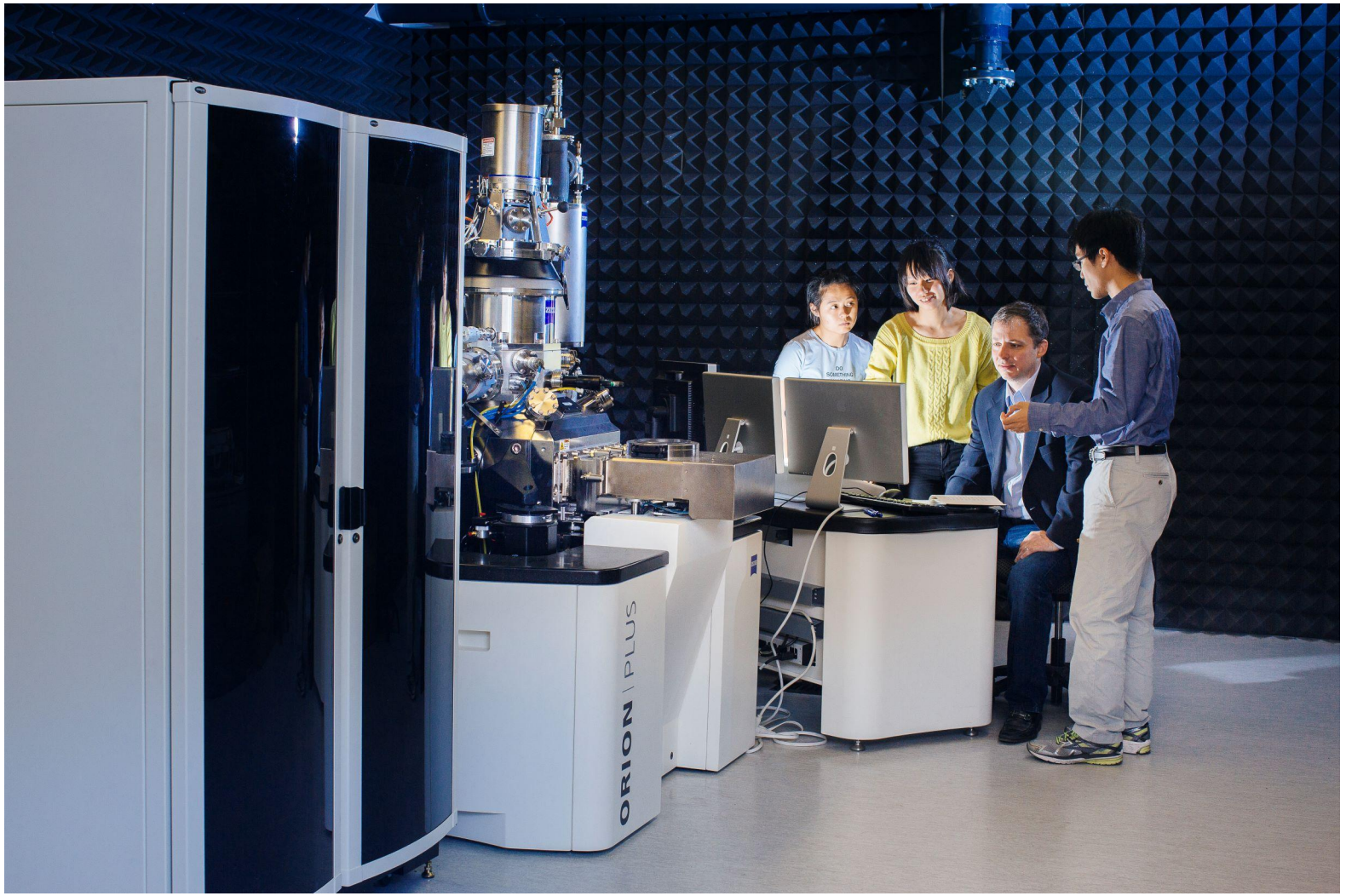
CAPABILITIES

- Zeiss Nanofab Helium Ion Microscope
  - Helium-Neon Gas Field Ion Source
  - Gallium Liquid Metal Ion Source
  - Gas Injection Ion Beam Assisted Materials Deposition
  - Raith Ion Nanolithography System
  - Nano-Prober System for Insitu Electrical Measurement
- Zeiss Orion Plus Helium Ion Micrscope
- 21 cm broad beam Kaufmann Argon Ion Source
- 16 cm broad beam RF Argon Ion Source
- 5cm Argon/Oxygen Hollow Cathode Ion Source

Helium Ion Microscopes

The ion Beam Lab at UCR operates two Zeiss helium ion microscopes.

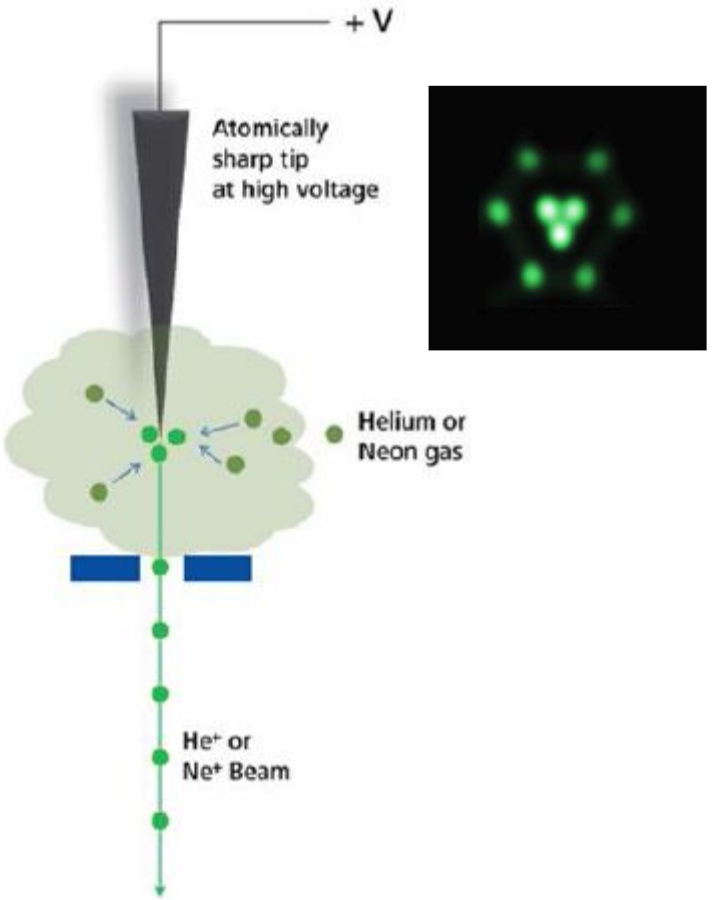
These systems offer unique nanofabrication capability with unprecedented sub-10 nm resolution

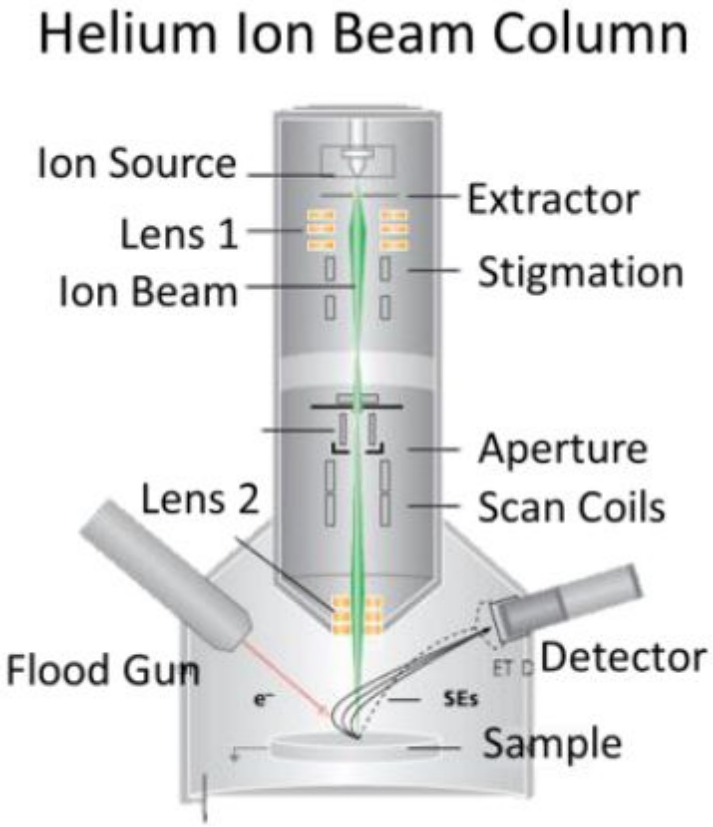


Focused helium ion beam operation

Carl Zeiss Orion
Gas field helium ion source

0.25 nm focused helium ion beam
~100 times smaller than Ga FIB





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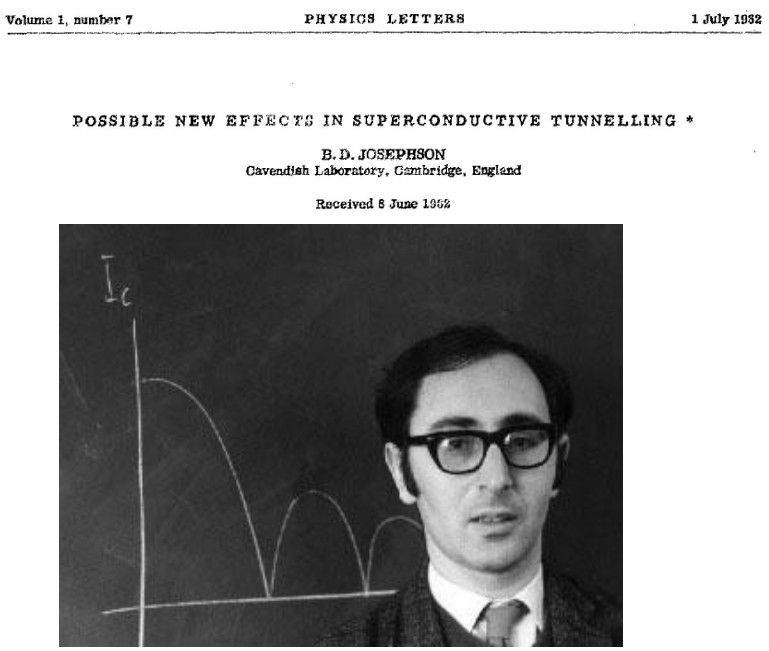
Josephson Junctions


Volume 1, number 7 PHYSICS LETTERS 1 July 1962

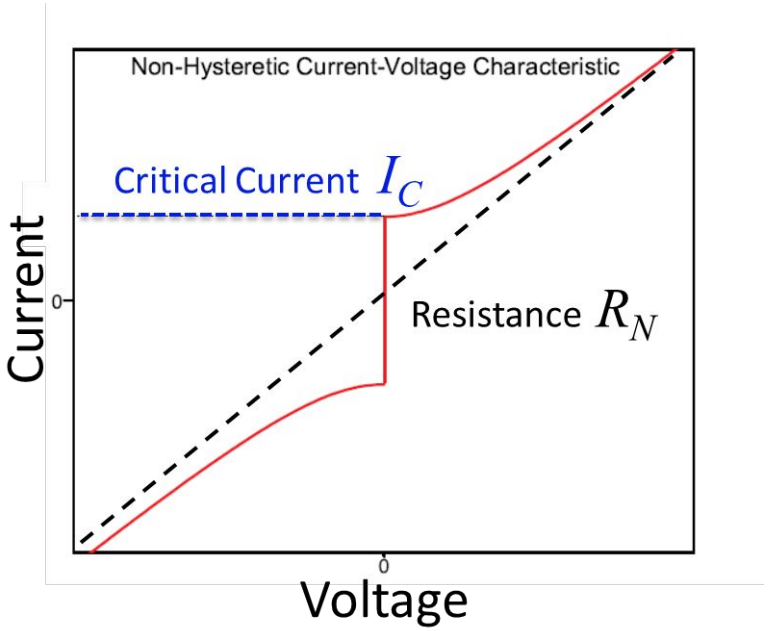
POSSIBLE NEW EFFECTS IN SUPERCONDUCTIVE TUNNELLING *

B.D. JOSEPHSON
Cavendish Laboratory, Cambridge, England

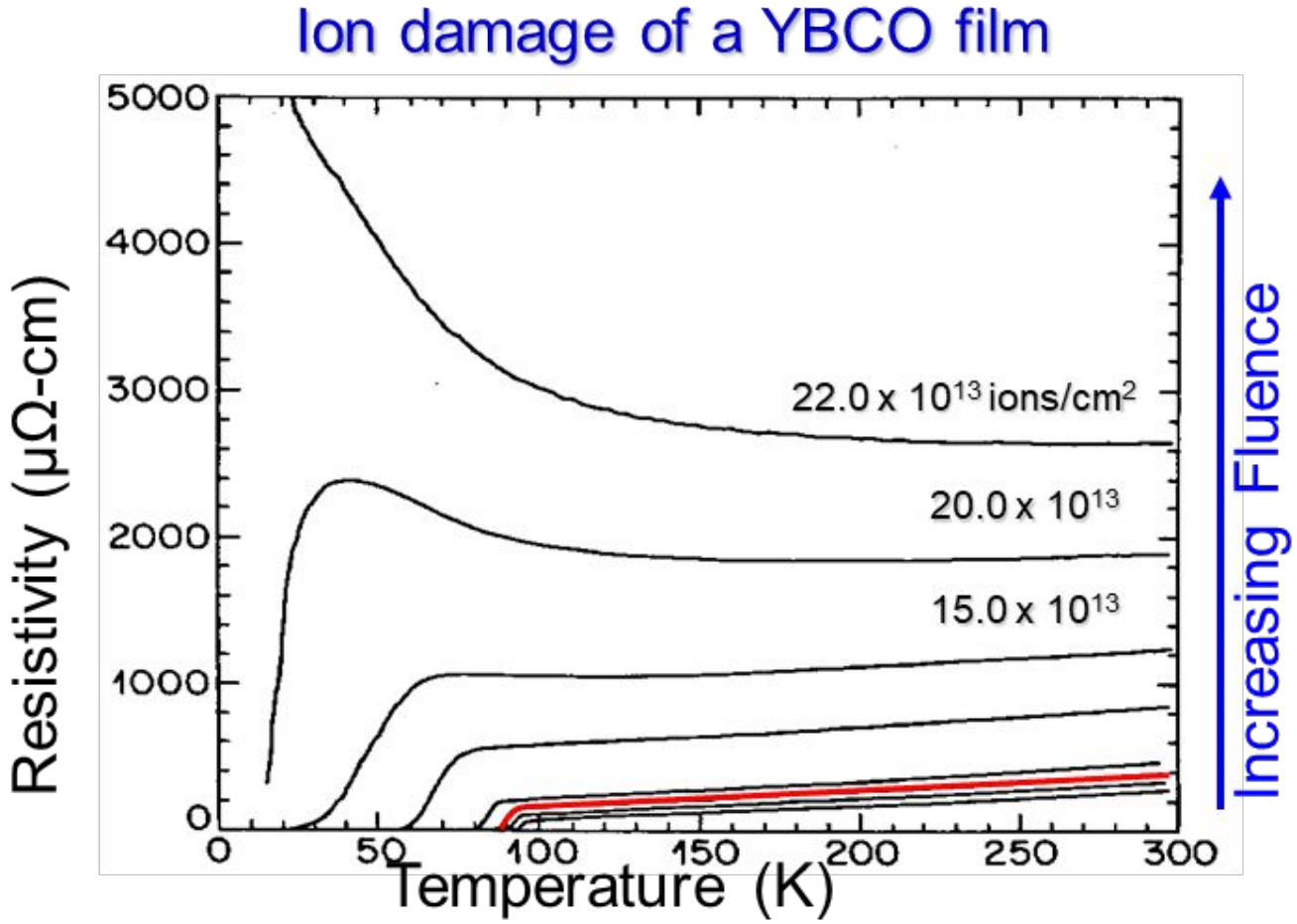
Received 8 June 1962

Brian Josephson

- Superconducting wave function
  $\Psi=\psi e^{i\theta}$
- First Josephson equation
  $I=I_C \sin\varphi$ where $\varphi\equiv(\theta_1-\theta_2)$
- Second Josephson equation
  $d\varphi/dt=2e/\hbar\ V$



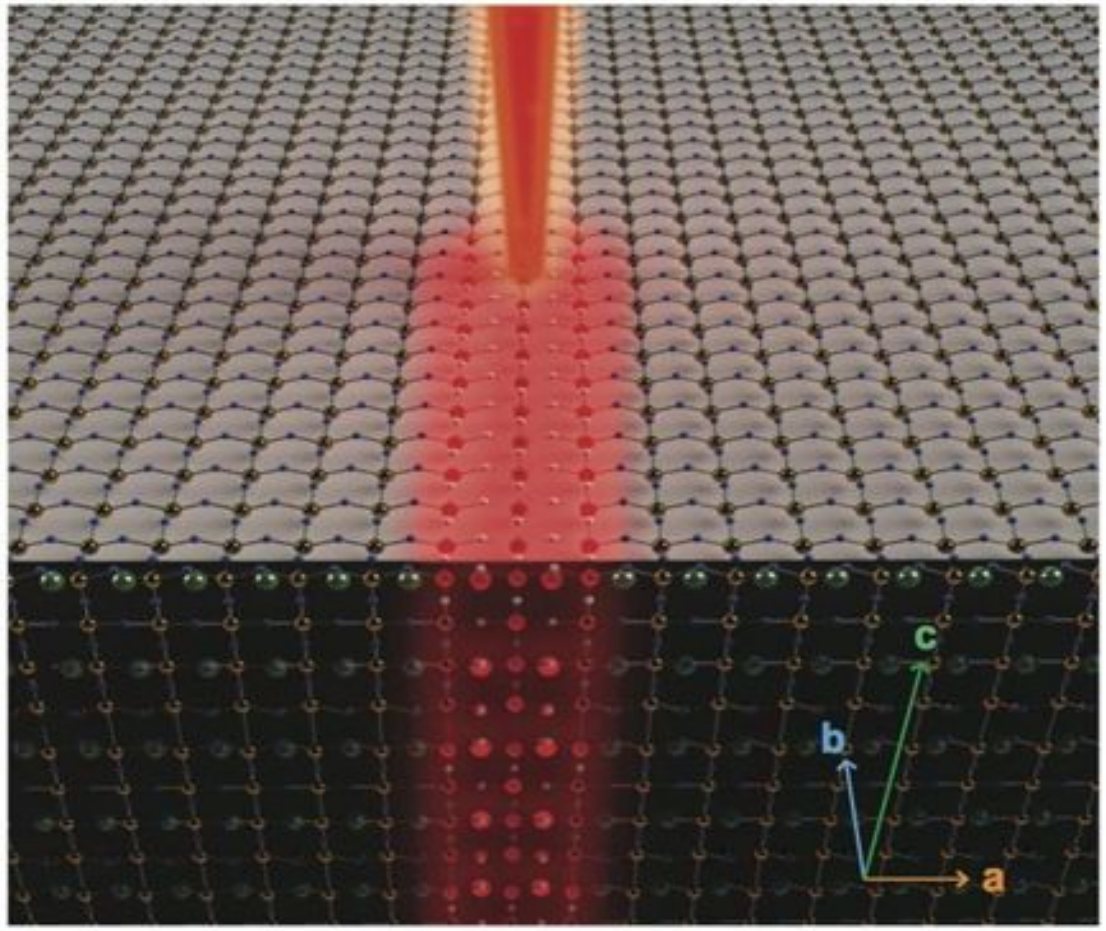
High TC Superconductor ion damage metal insulator transition

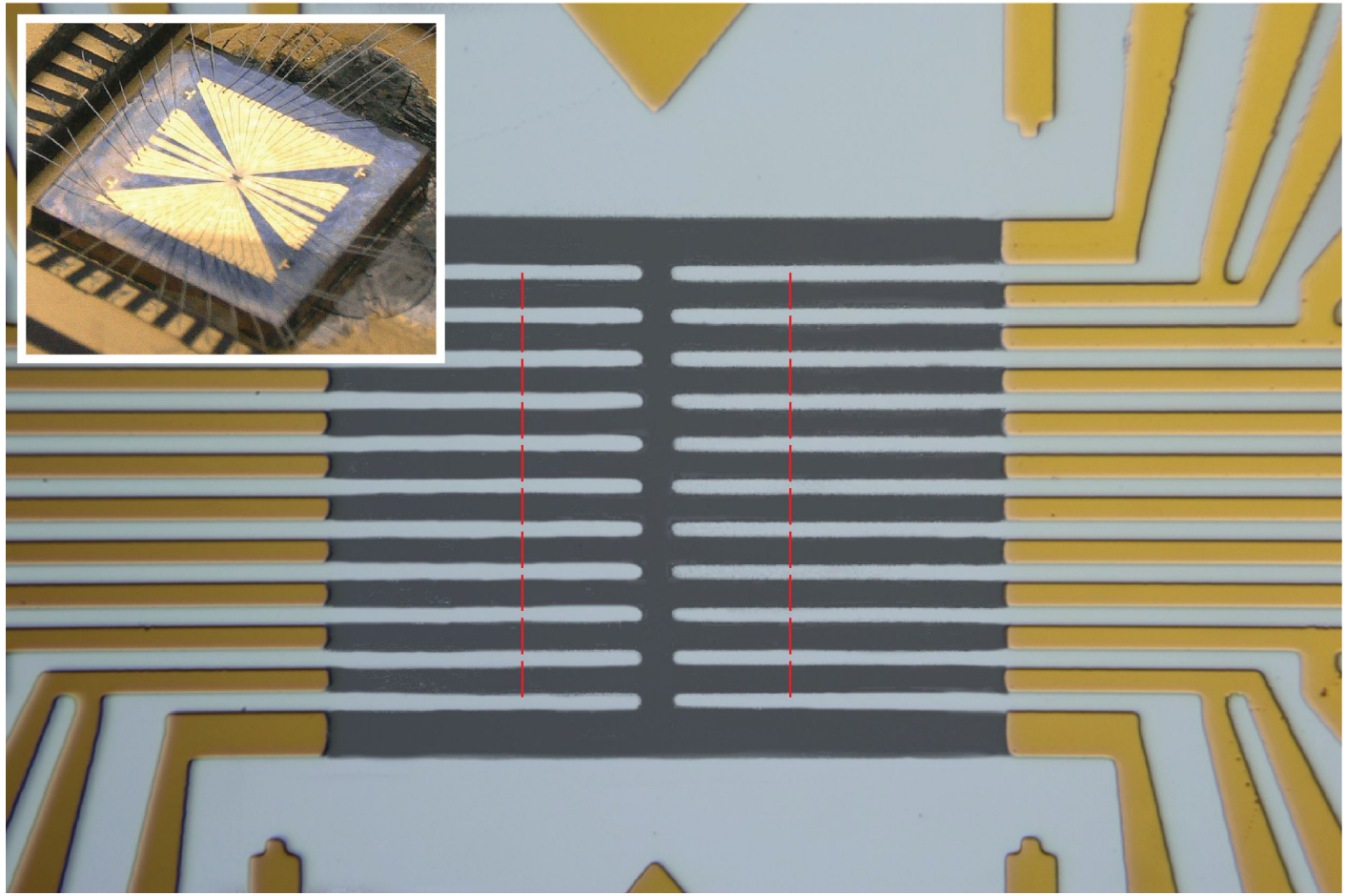


1 MeV Ne^+ Ions, 0.0, 0.1, 2.5, 4.0, 10.0, 15.0, 20.0, 22.0 x 10^{13} ions/cm^2

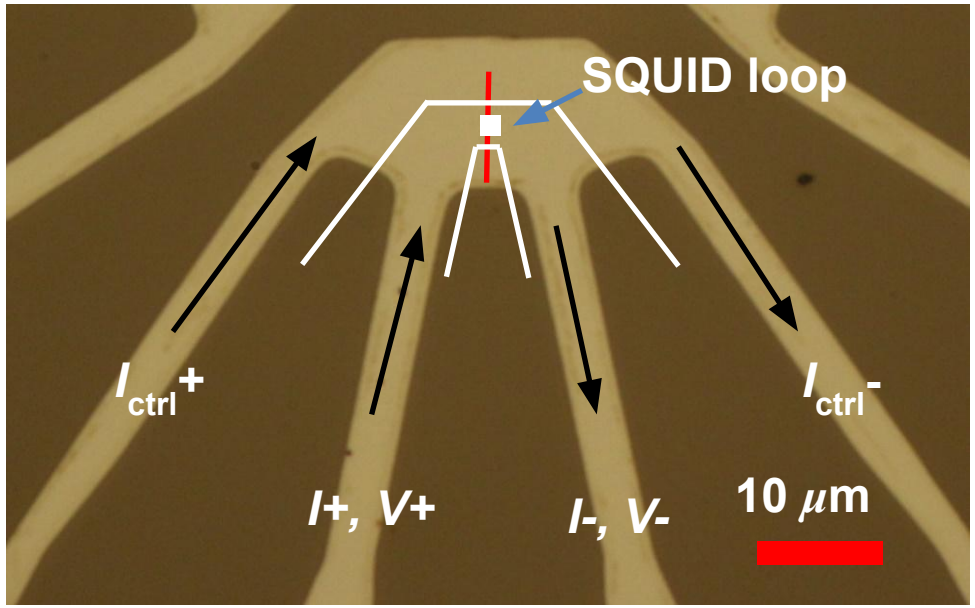
Appl. Phys. Lett. 53 (11), 12 September 1988

YBCO junction process



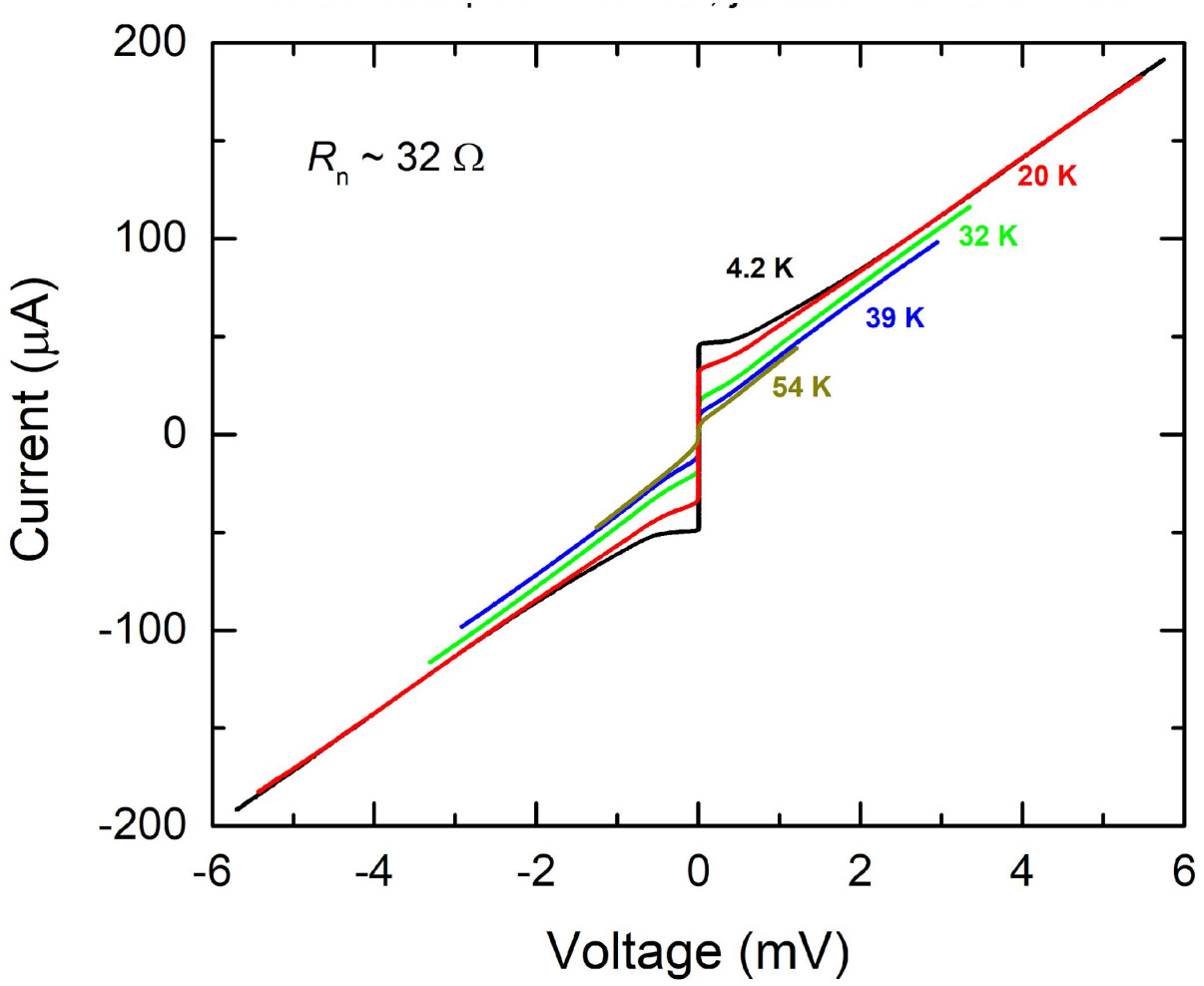


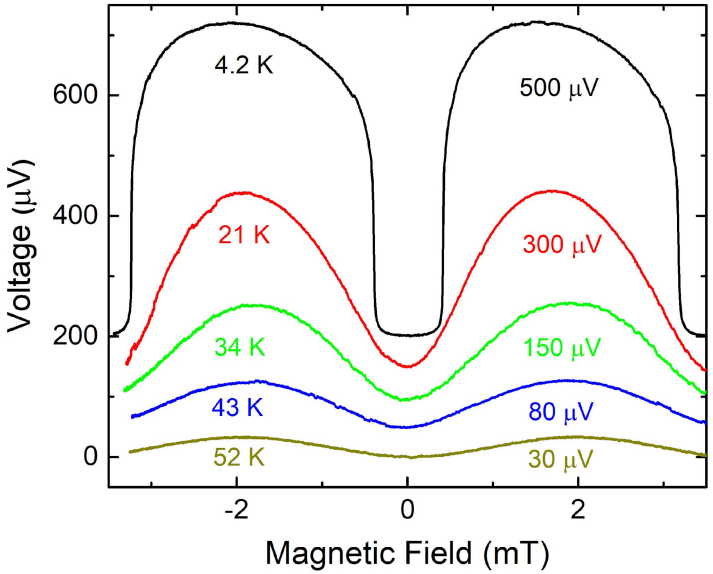
Direct-write nano-SQUID

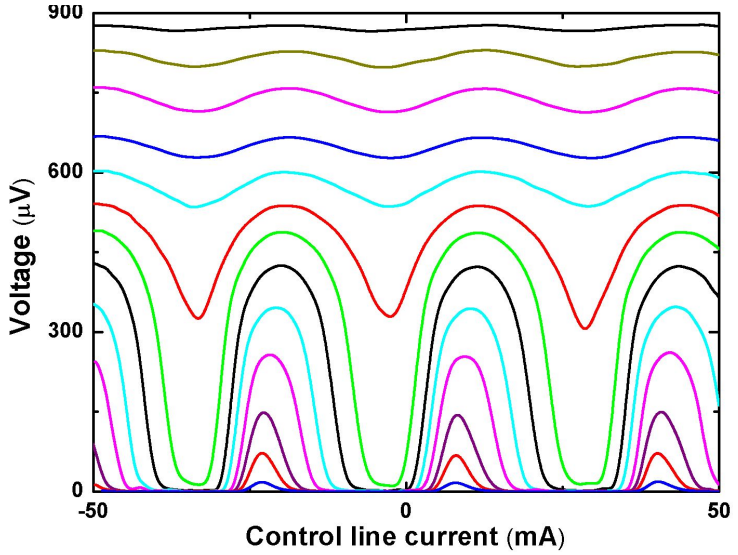


Li, H.., et al. 2020. High-transition-temperature nanoscale superconducting quantum interference devices directly written with a focused helium ion beam. *Applied Physics Letters*, *116*(7), p.070601.

Direct-write nano-SQUID transimpedance amplifier







Ion Beam Lab Future Roadmap

The IBL recently was awarded a $5M DOE grant to support education in quantum circuit edit and materials modification. This will support:

- Professional staff
  - Rechargeable to outside users
- Student training
  - Undergraduate research opportunities
- Student fellowships at Sandia National Laboratory
  - For collaborative work with researchers at Sandia