Cuprate superconductivity in the extreme 2D limit

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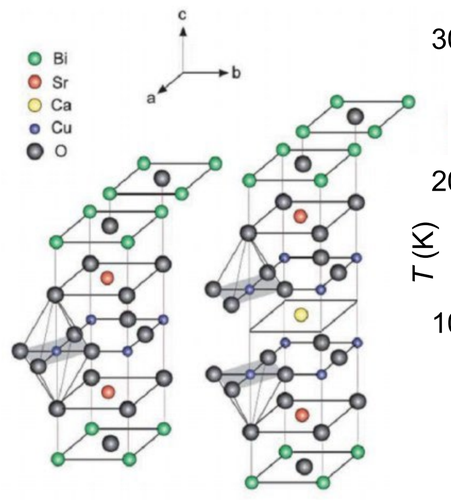
Introduction

Why we study monolayer Bi2201

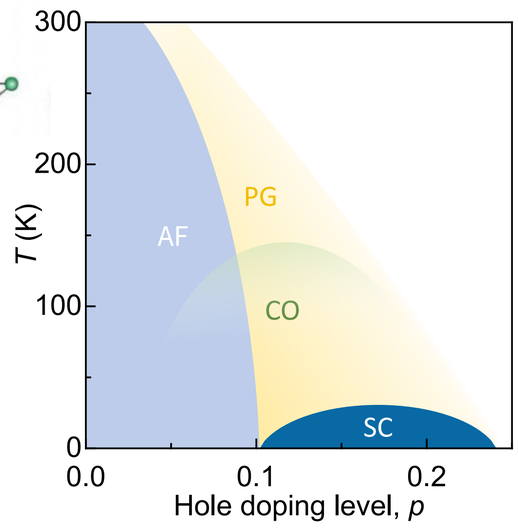
- Simple system for studying high-temperature superconductivity without intralayer coupling
- Tunable system for exploring the complicated phase diagram

Atomic structure



Bi2201 Bi2212

Phase diagram

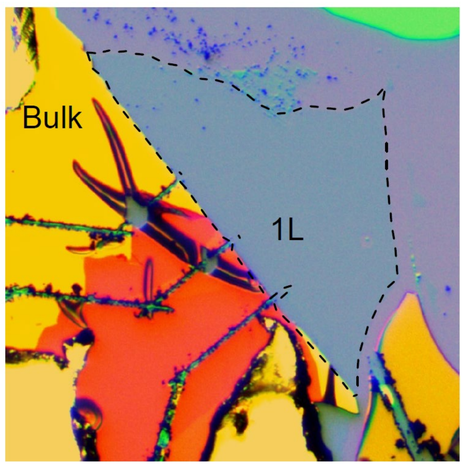


Fabrication method

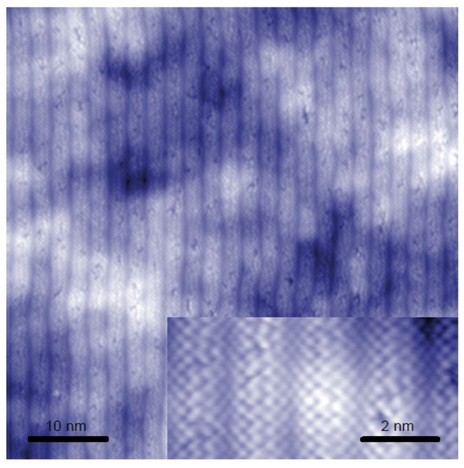
Intrinsic monolayer Bi2201 was obtained

- Hydrogen bond assisted exfoliation at cryogenic temperature
- Cold-welding electrode fabrication

Optical image of 1 L Bi2201 device

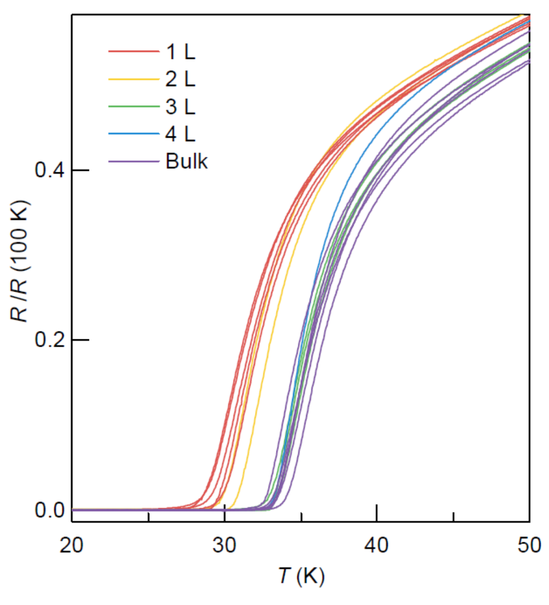


STM topography of 1 L Bi2201

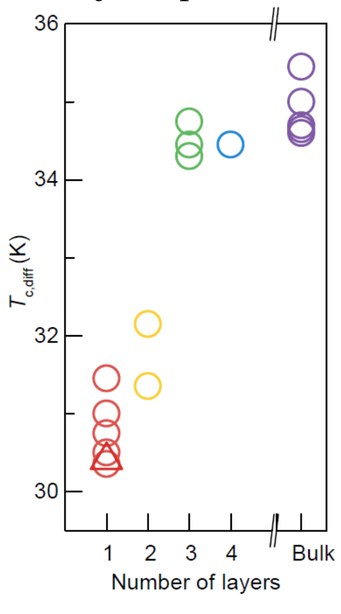


Decreased T_c in 1 L Bi2201

R-T comparison



T_c comparison



Possible reason of T_c decrease

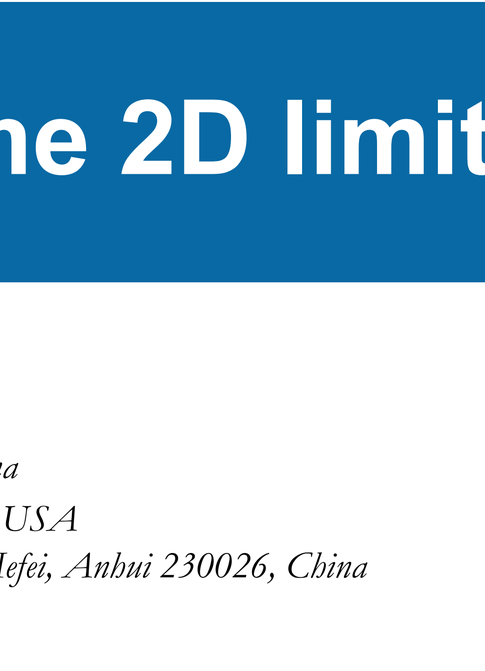
- Oxygen dopants loss during device fabrication ×
- Sample degradation during device fabrication ×
- Disorder increase during doping tunning process ×
- Intrinsic dimensional effect of cuprate high-temperature SC ✓

Large-range and reversible tunability

Vacuum annealing

Ozone annealing

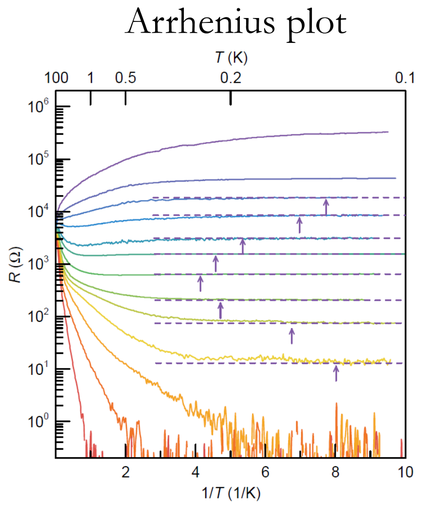
Phase diagram



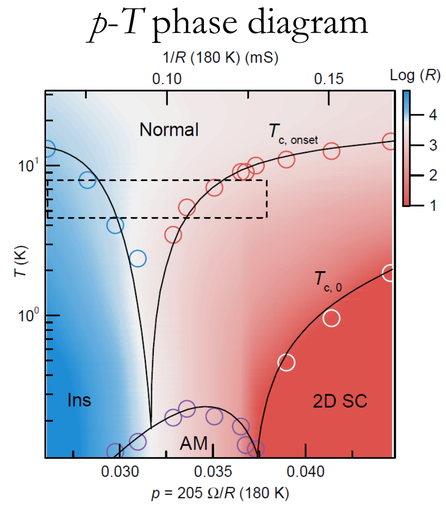
- Carrier density ~ 10^{14} cm^{-2}
- Dope electrons/holes through annealing in vacuum/ozone
- Reversible tunning

Anomalous metal phase in 1 L Bi2201

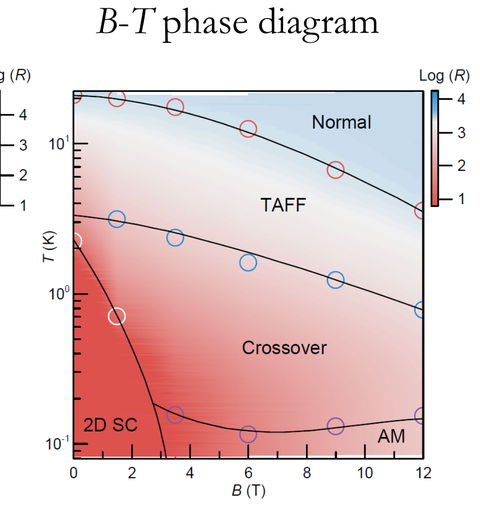
Arrhenius plot



p-*T* phase diagram

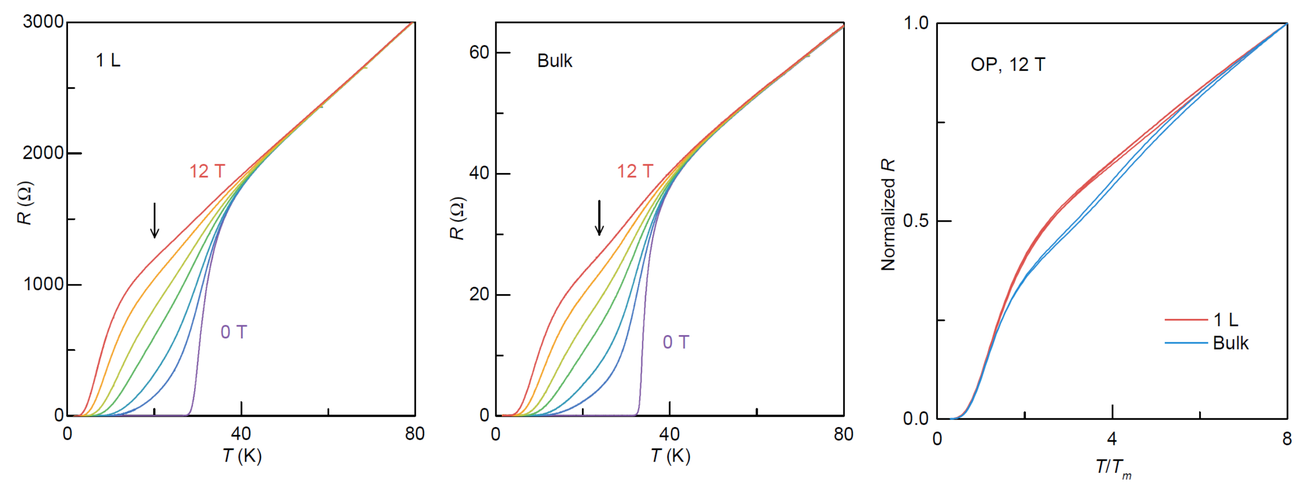


B-*T* phase diagram



- Anomalous metal is one of the ground-state of 2D cuprate superconductors

Enhanced vortex motion in 1 L Bi2201



- Vortex liquid regime
- Energy barrier of vortex motion in 1 L Bi2201 is lower
- Enhanced vortex motion leads to stronger dissipation

Summary

- 1 L Bi2201 is a highly tunable 2D superconductor.
- Optimal T_c in 1 L Bi2201 is ten percent lower than that of bulk.
- Vortex motion is enhanced in 1 L Bi2201.
- Anomalous metal is the intermediate phase in the superconductor-insulator transition of 1L Bi2201.