Preparation and Characterization of Flux-controlled Superconductor-based Neuromorphic Computing Device

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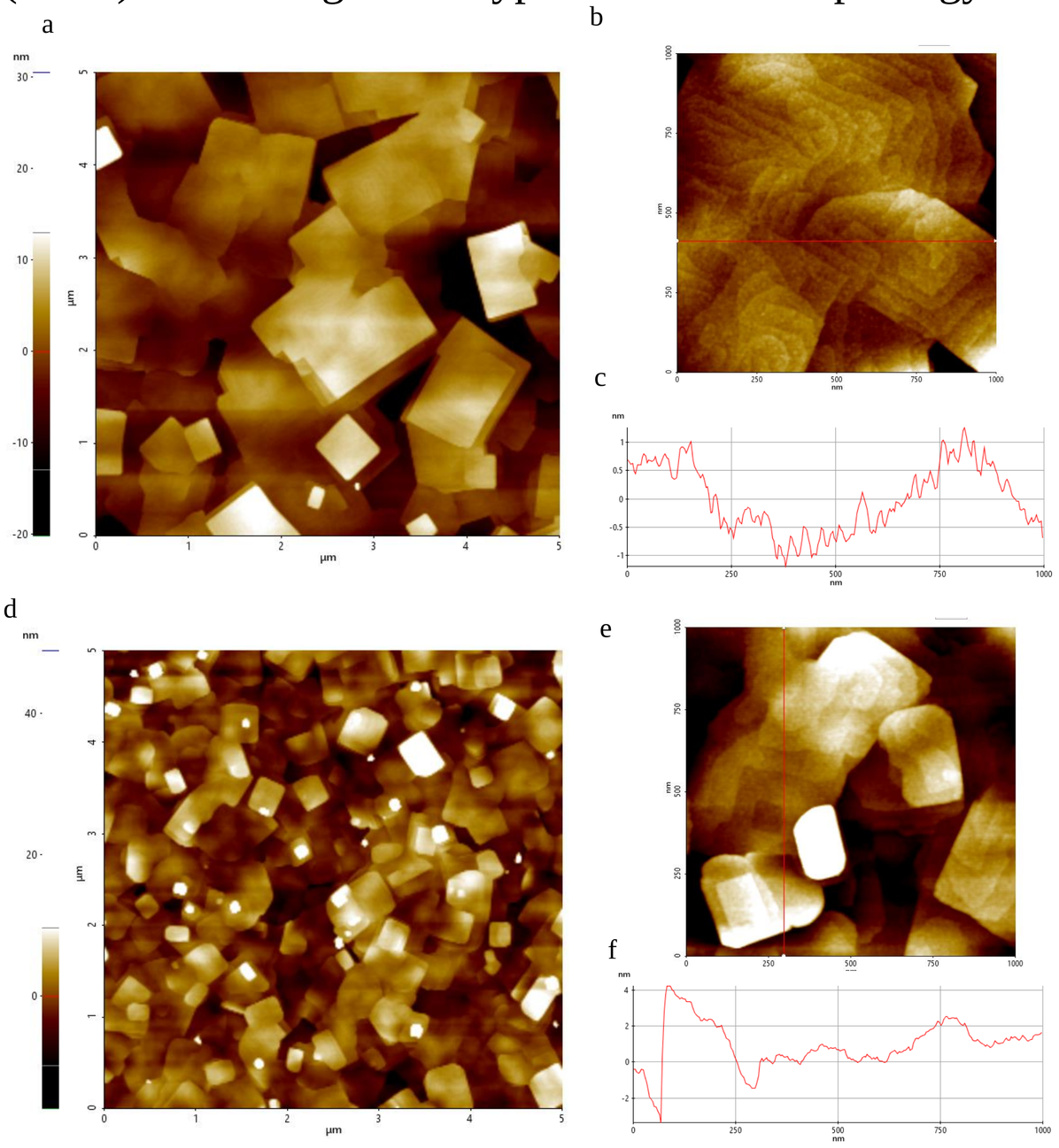
INTRODUCTION

Neuromorphic computing, the mimic of functionality of neural systems in organisms, overmatches traditional von Neumann architecture in flexibility, concurrency and energy effectivity. Random systems with inhomogeneous electron doping has proven to fulfill classification and other tasks of artificial intelligence (AI). We propose a neuromorphic system based on natural random Josephson junction (JJ) arrays, which is controlled by magnet flux under cryogenic conditions.

GROWTH OF IRON-BASED FILMS

The random JJ arrays are realized through iron telluride (FeTe), a semiconductor with antiferromagnetic (AFM) pairing, but turns into superconducting after annealing in oxygen atmosphere. FeTe has a tetragonal lattice and is a granular superconductor with superconducting islands connected through normal-state areas playing the role of JJs.

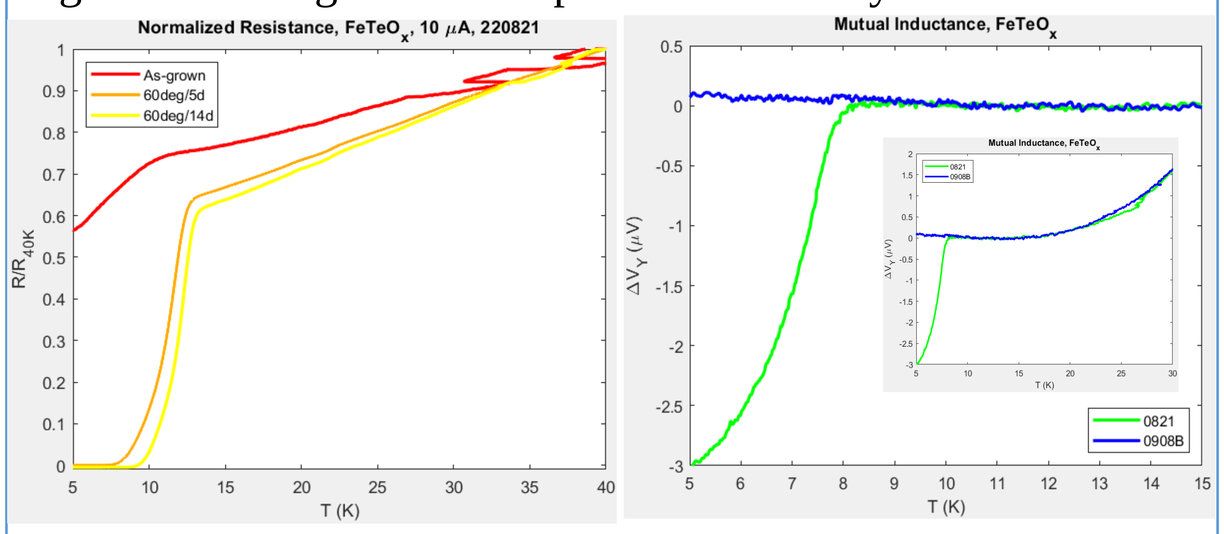
FeTe films are grown through molecular beam epitaxy (MBE). Following are its typical surface morphology.



Typical morphology of 5×5, 1×1 μm and line cut. a~c grown on Al_2O_3, d~f on silicon.

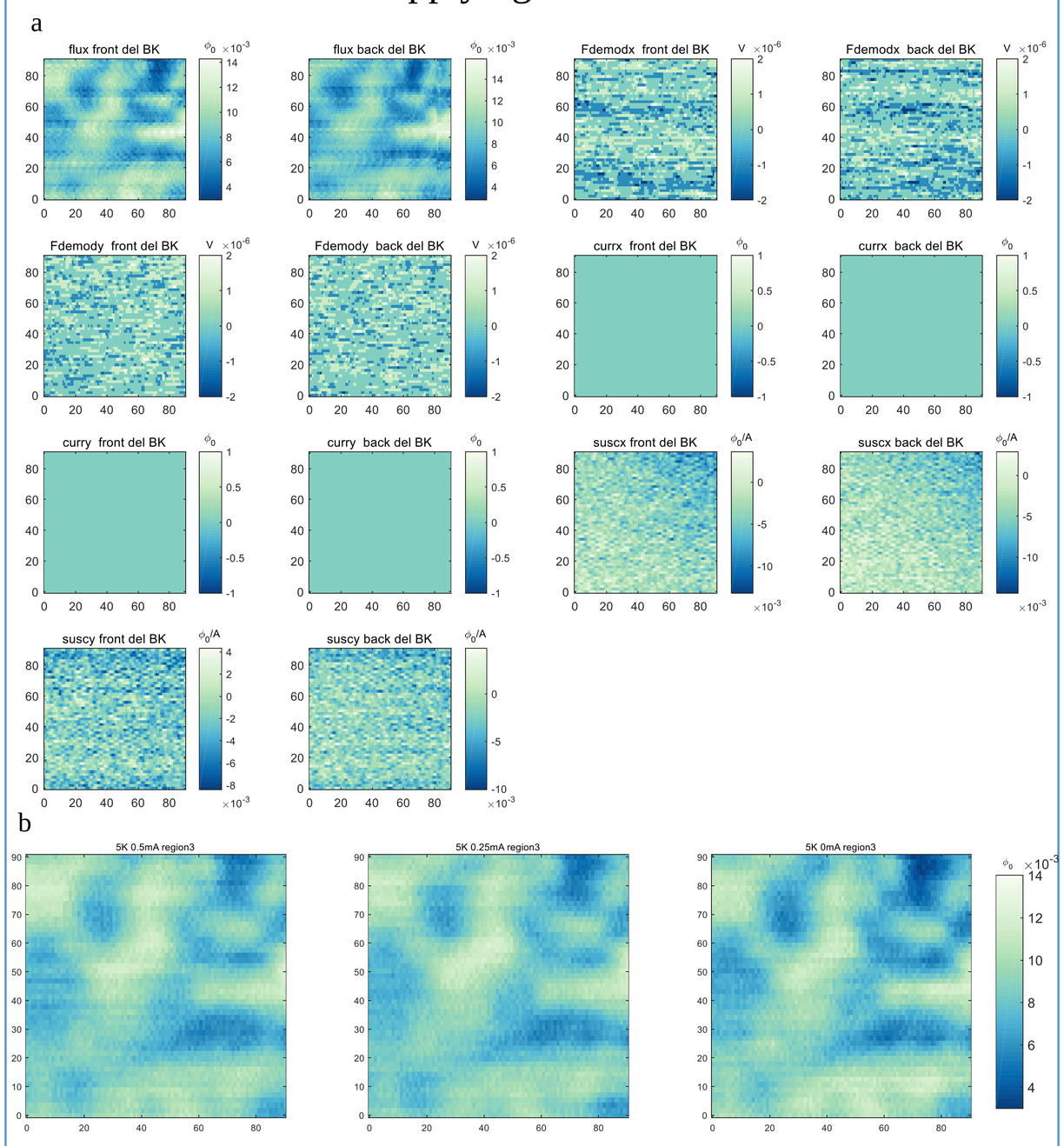
CHRACACTERIZATION OF FILM QUALITY

Resistance and mutual inductance shows that, annealing in oxygen atmosphere can yield a superconducting zero resistance temperature of ~ 10K, with obvious diamagnetic signal indicating nonzero supercurrent density.



MAGNETIC RESPONSE OF NONLOCAL DRIVING CURRENT

The sample is patterned with electron beam lithography, and probed with scanning superconducting inference device (sSQUID). Adding driving current nonlocally (~1 mm away) gives magnetic response, reflected from DC magnetic flux increment by a magnitude of $m\Phi_0$. Difference in susceptibility is not as obvious after applying the current.



a. Scanning of a single region (80×80 μm), giving information on intrinsic magnetic flux, susceptibility and so on. b. Comparison of DC flux of a region under different nonlocally applied B field far away.

REFERENCES

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