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Physical Unclonable Function Generator based on colloidal Quantum Dots

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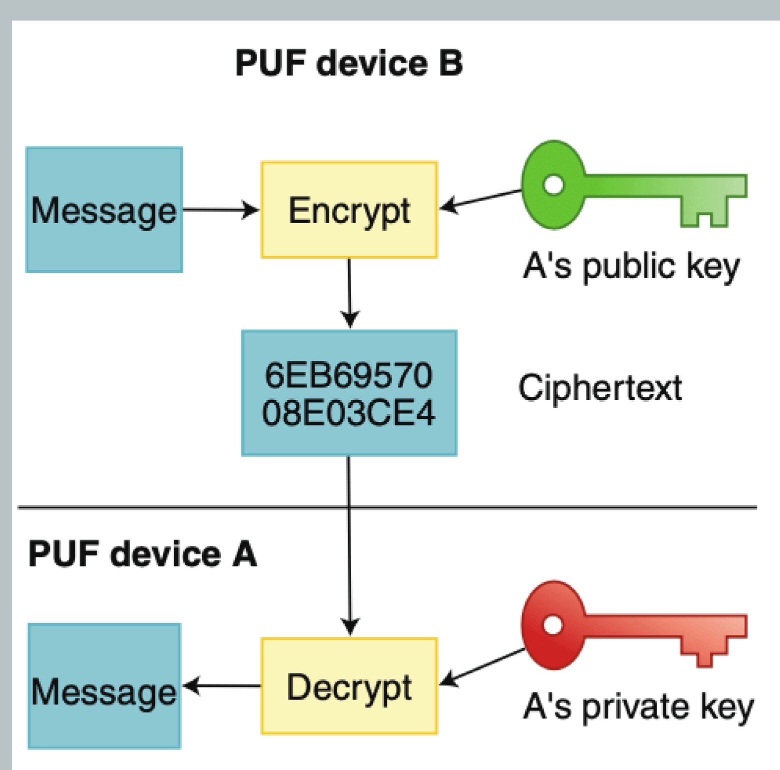
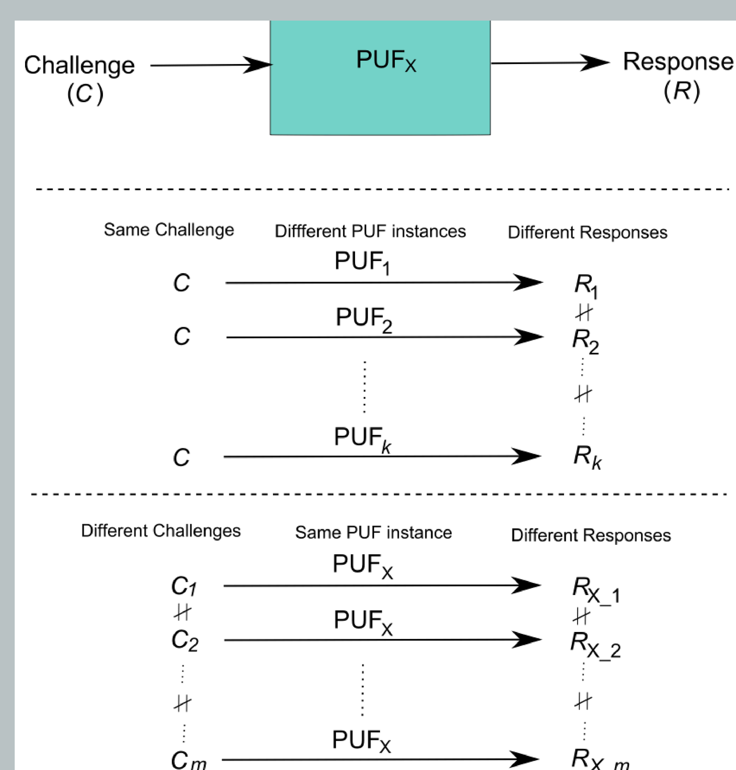
Introduction

A physical unclonable function (PUF) is a device that exploits inherent randomness introduced during nanoscale manufacturing to give a physical entity a unique 'fingerprint'.



Employing a PUF within the public key infrastructure

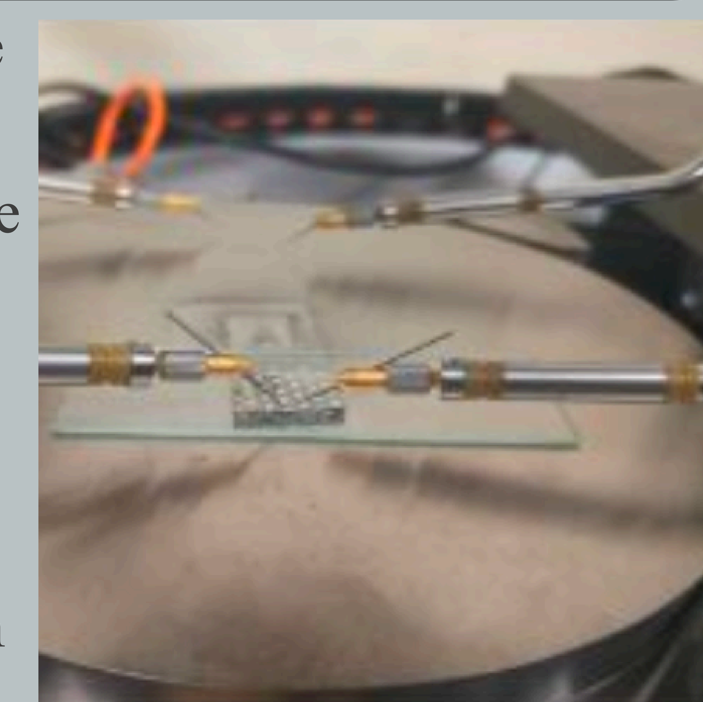


A PUF can be simply treated as a black box whose response is determined by a complex function.

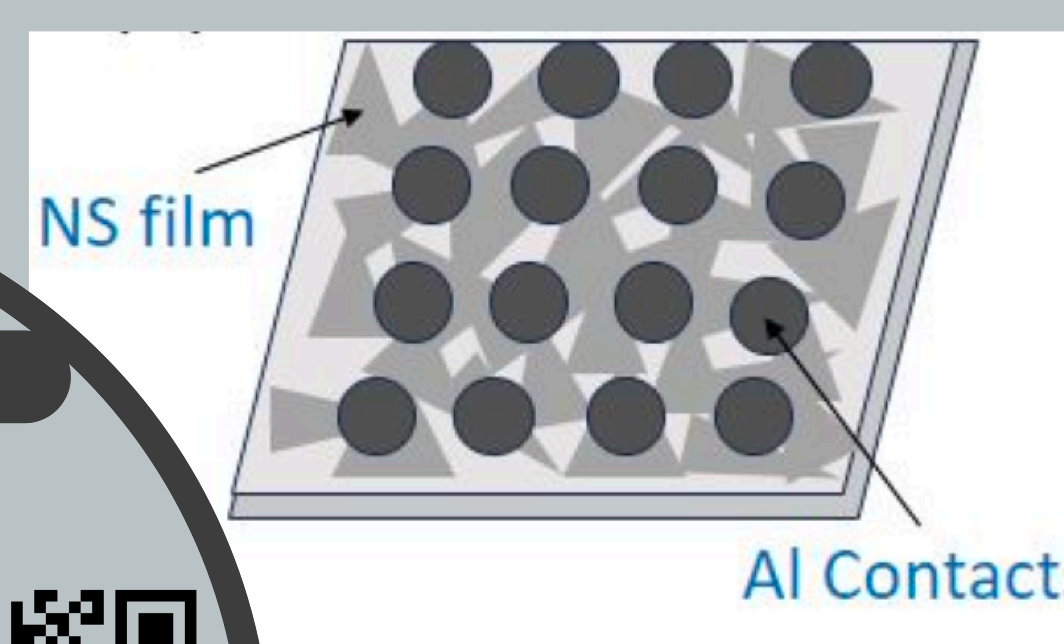
With the rapid increase in cyberthreats and counterfeiting along with vulnerability of traditional cryptographic systems towards AI/ML attacks, PUFs offer a simple alternative to generating unique volatile digital keys which are easy to build but practically impossible to duplicate.

Methodology

- Current-Voltage characteristics are obtained using DMM for Gold nanoparticles suspended in a citrate buffer solution by drop-casting the solution on a silicon wafer.
- 2-dimensional networks of nanostructures made of aluminium are used to implement the PUF.
- Keithley source meter and probe station used to measure resistances at different positions.



Resistance measurement in 2D Aluminium mesh PUF device with probe station using tungsten probes.



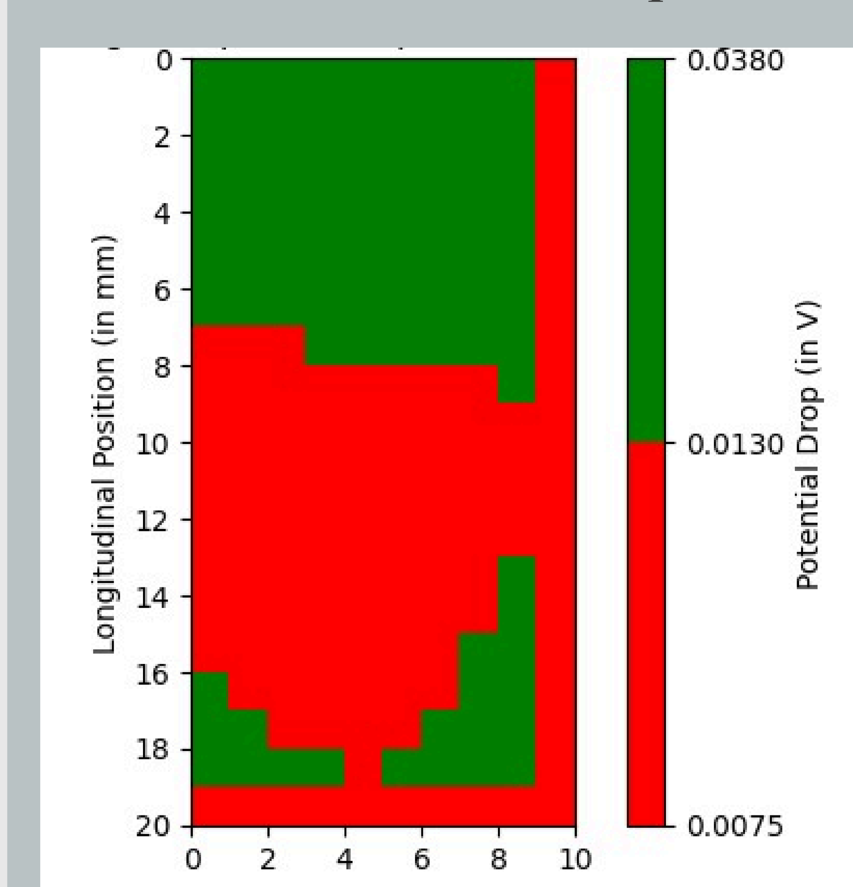
PUF device based on 2D Aluminium mesh nanostructure random networks.

Objectives

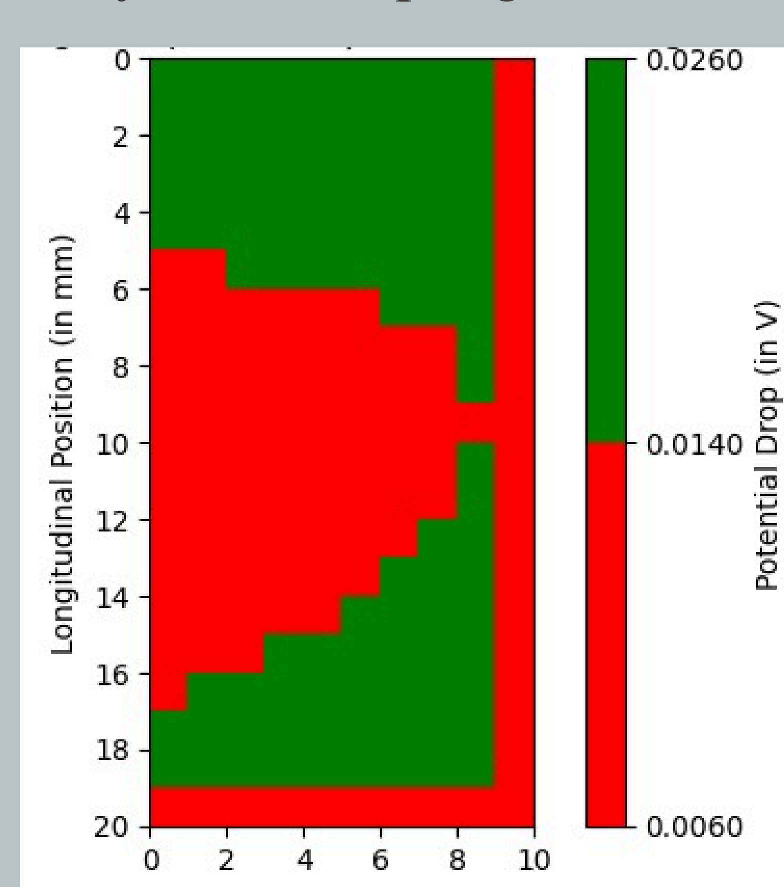
Fabricate a Function generator using quantum dots to enhance authentication system security while simultaneously being non-replicable.

Results (Gold nanoparticles)

Significant switch in resistance and voltage values is observed owing to exponential relation between current and voltage in quantum regime.
More uniform distribution of high-low voltage states could be achieved for quantum dots by finer sampling.



Interpolated voltage drop colour map with thresholding for 10 nm QDs



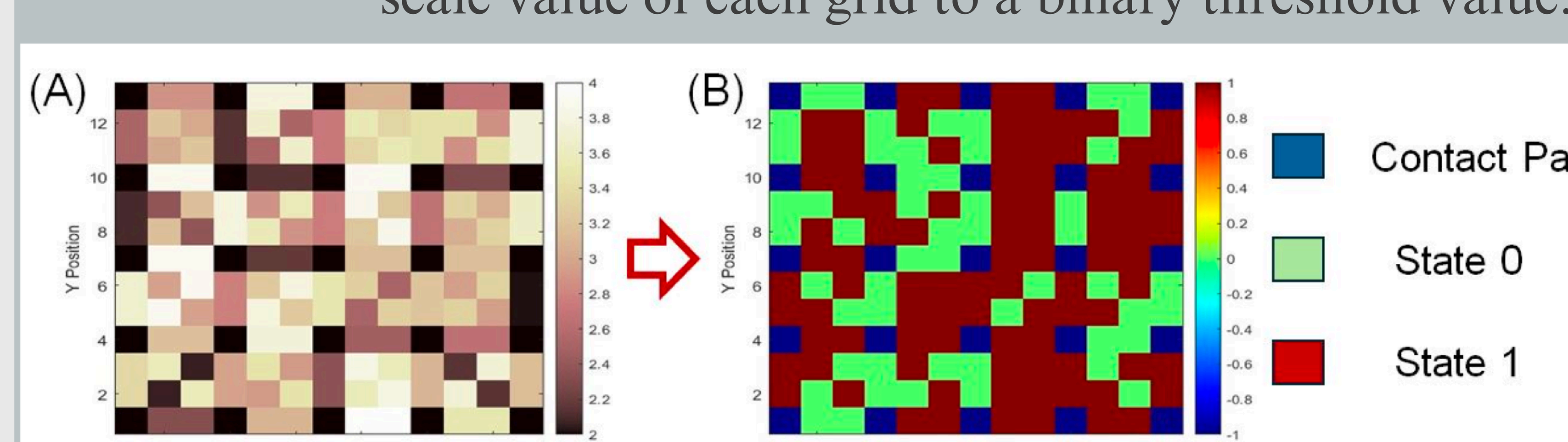
Interpolated voltage drop colour map with thresholding for 100 nm QDs

$$I \propto V \exp\left[-\frac{4\pi d\sqrt{2m^{*}\phi_B}}{h}\right]$$

ϕB is the barrier height,
m is the free electron mass,
q is the electron charge,
h is Planck's constant,
d is the width of the barrier.

Results (Aluminium nanostructure)

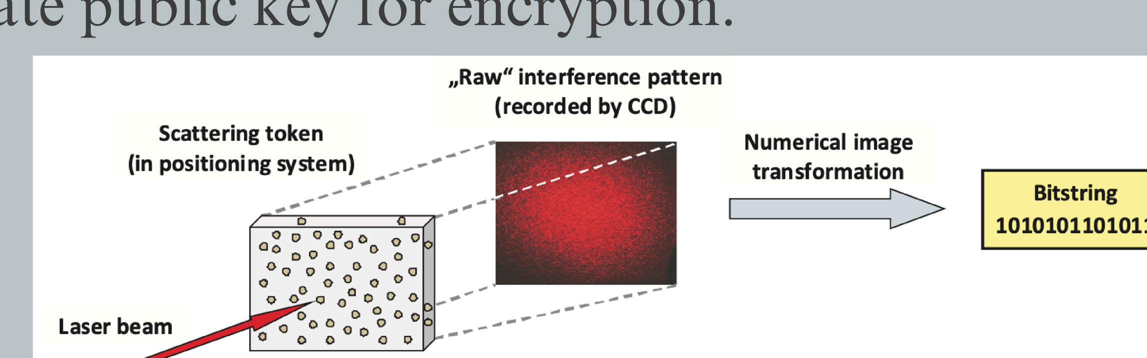
Generated resistance maps for aluminium nanostructure have equitable distribution of 0 and 1 states, leading to a hamming weight of 0.5.
A QR code is obtained by comparing the colour scale value of each grid to a binary threshold value.



(A) Resistance map of Al mesh (B) Unique identification code by binary encoding

Future work:

- Analysis of fabricated devices under different conditions and sizes of quantum dots.
- Fabrication of Optical PUF using CdSe quantum dots to generate public key for encryption.



References:
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