Influence of Rare Earth (Y^{3+}) on Structural, Dielectric and Magnetic Properties of Cobalt ferrite nanoparticles

K.L. Routray and D. Behera, Department of Physics and Astronomy NIT Rourkela

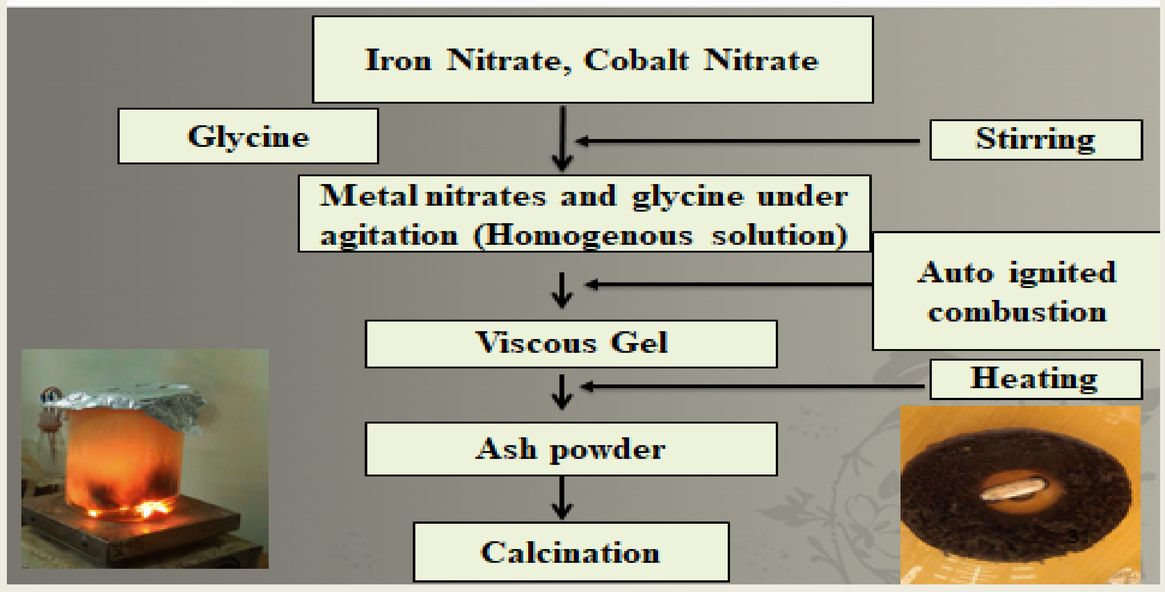
Abstract:

Present work focusses on the fabrication of rare Earth (Y^{3+}) substituted Cobalt ferrite $CoFe_{2-x}Y_xO_4$ (x = 0.0, 0.1, 0.3, 0.5, 0.7) employing efficient, cost-effective glycine nitrate method. The phase formation was confirmed by means of X-ray diffraction analysis that indicated a formation of an extra orthoferrite phase after an increased Y^{3+} (x=0.7) concentration. FESEM micrographs demonstrated uniformly homogenous and agglomerated particles with a decrease in average grain size with increasing Y^{3+} content owing the larger ionic radii of Y^{3+}. All the prepared samples exhibit semiconducting behaviour and is explained using Maxwell- Wagner equation. Complex impedance and complex electric modulus plots were further studied for complete contribution of grains and grain boundary resistances to conduction and resonance frequencies respectively. Magnetic studies by Vibrating Sample Magnetometer (VSM) show that saturation magnetization (M_s) decreases with increase in Y^{3+} concentration. Y^{3+} doped cobalt spinel ferrites are found to have dramatic changes in electrical and magnetic properties that find suitability in magneto-recording devices. From the Mössbauer spectra, isomer shift (δ), quadrupole splitting (QS) corresponding to the tetrahedral [A] site and octahedral [B] sites and hyperfine field have been extracted by the standard least square fitting program NORMOS..

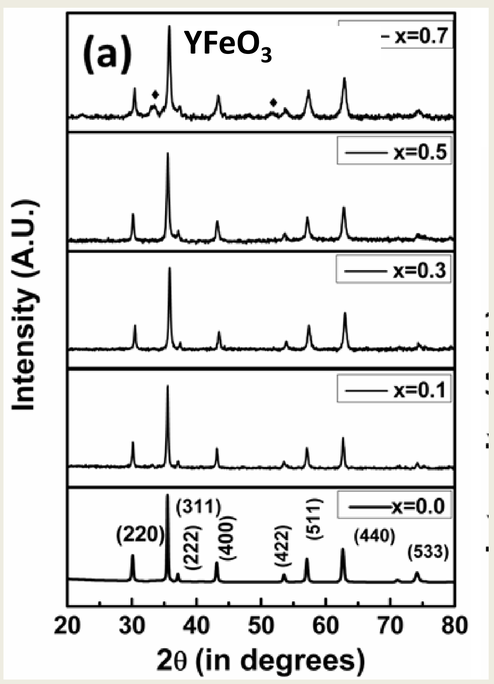
Motivation:

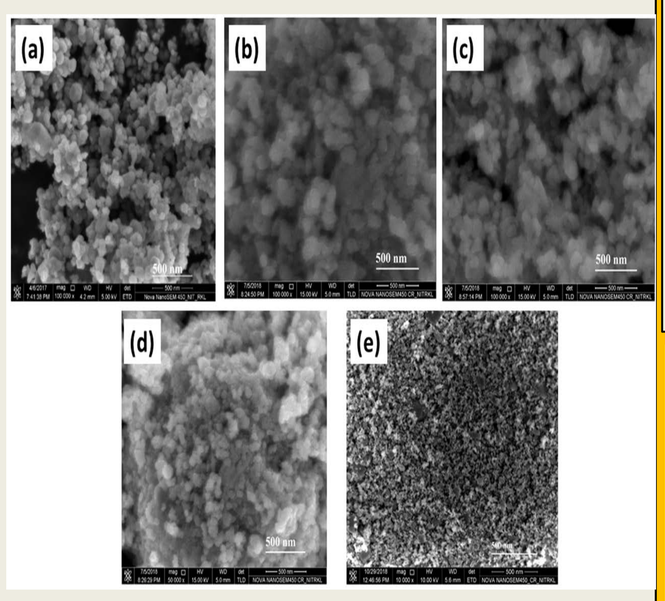
- ✓ Synthesis of nano-sized cobalt ferrite (CFO)
- ✓ Taking into consideration the importance of CFO it has been decided to improve the structural, electrical, dielectric and magnetic properties by substituting RE (Y^{3+}) ion .
- ✓ Successful incorporation of RE into cobalt ferrite lattice upto 70% ($CoFe_{2-x}Y_x0_4$ (x= 0.0, 0.1, 0.1, 0.3, 0.5, 0.7)
- ✓ To investigate the dielectric and magnetic properties in the presence of ortho-ferrite phase.
- ✓ Electrical and Dielectric Characterizations (variation with temperature and frequency both) of the prepared ceramics
- ✓ Magnetic Characterizations:
  M-H Hysteresis Loop and Mossbauer study
- ✓ Drawing a useful conclusion based on the outcomes so as to find the scope for application of the synthesized RE substituted CFO.

Experimental procedure



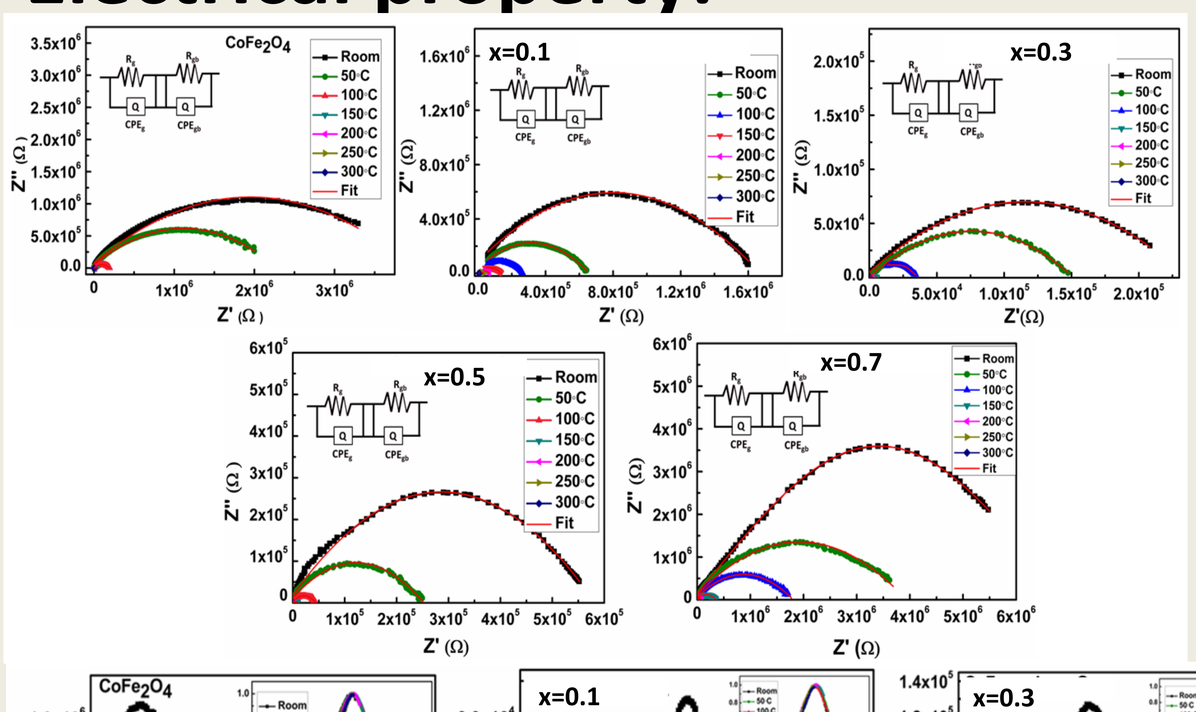
Structural Characterization:

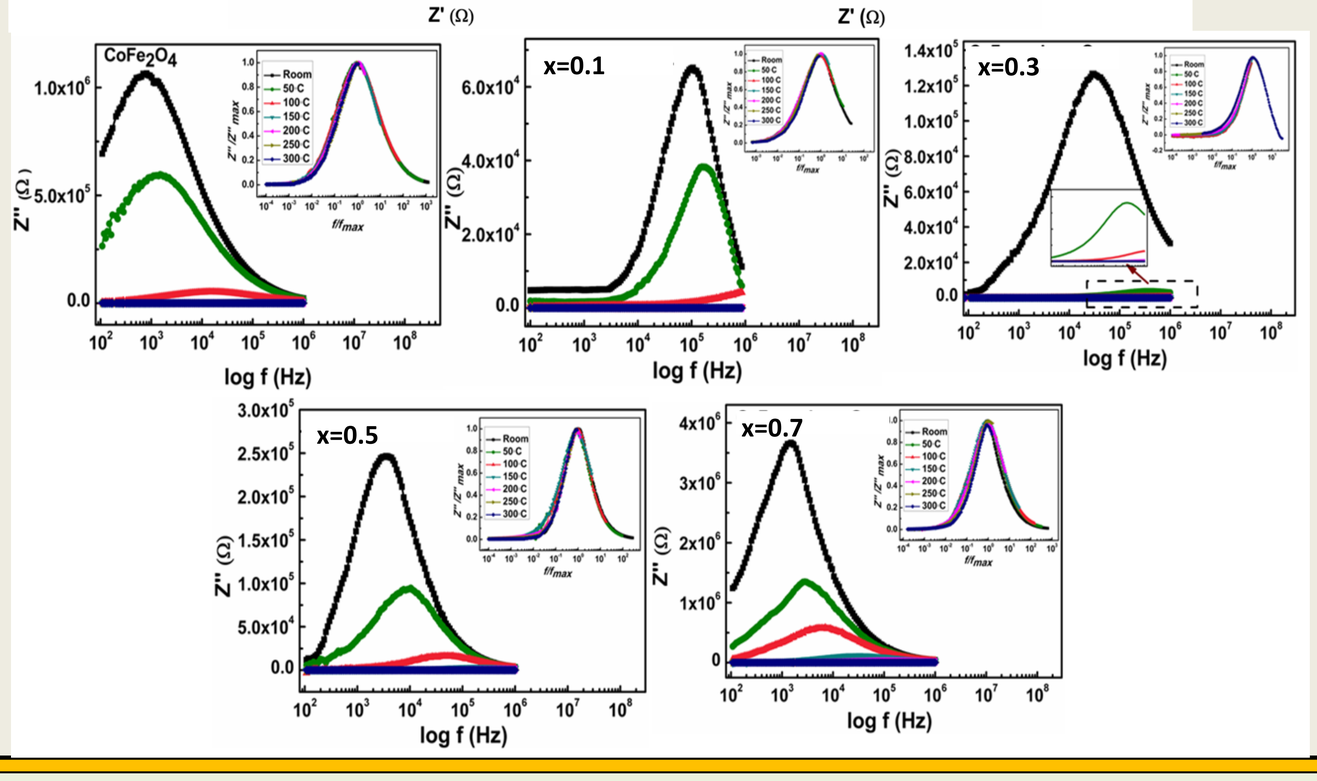




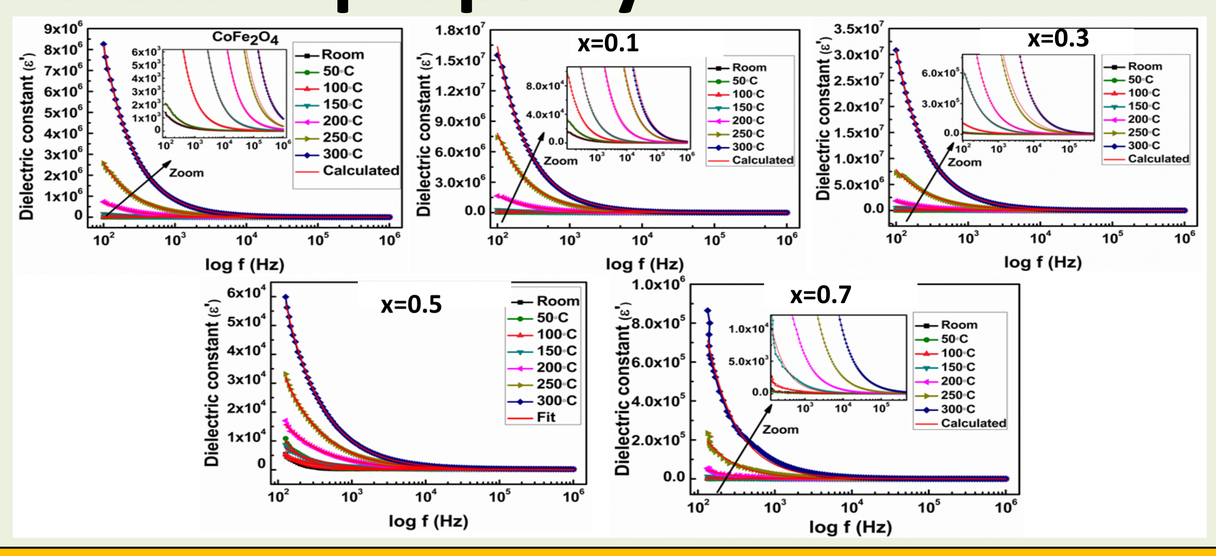
- Agglomerated particles with particle size less than 50 nm .
- With increasing Y^3 concetration reduction in particle size

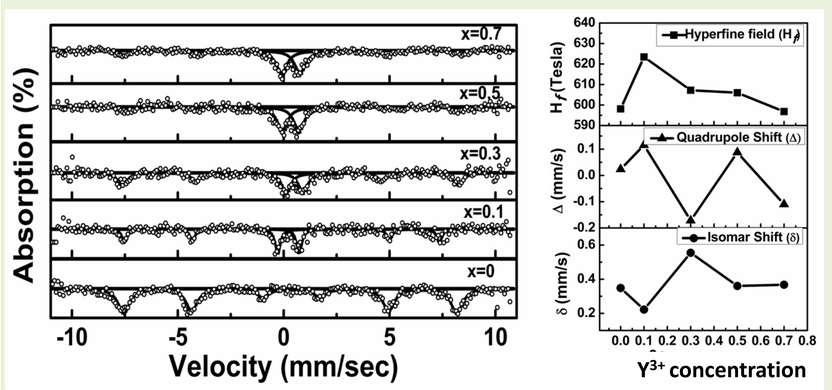
Electrical property:





Dielectric property:

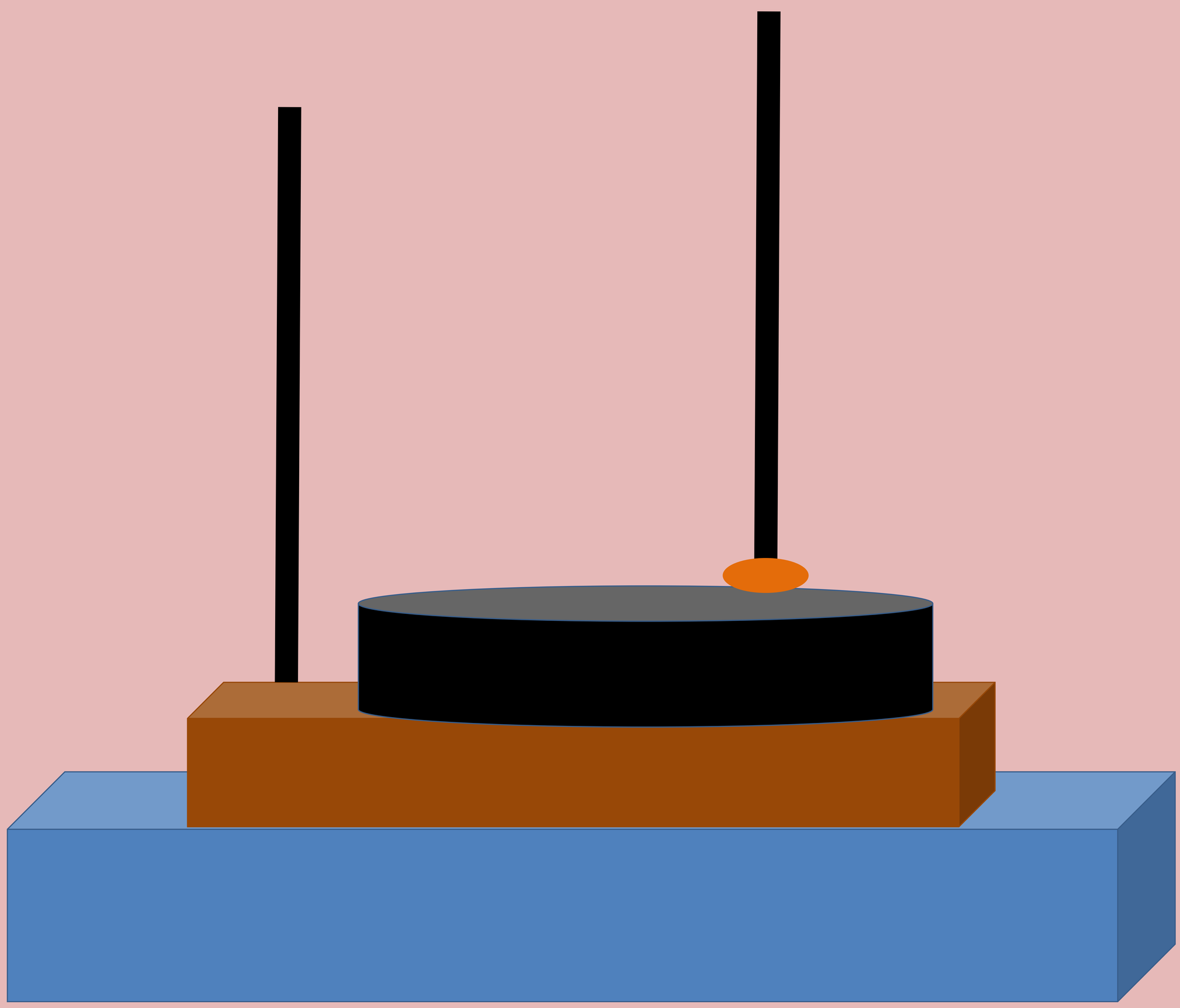


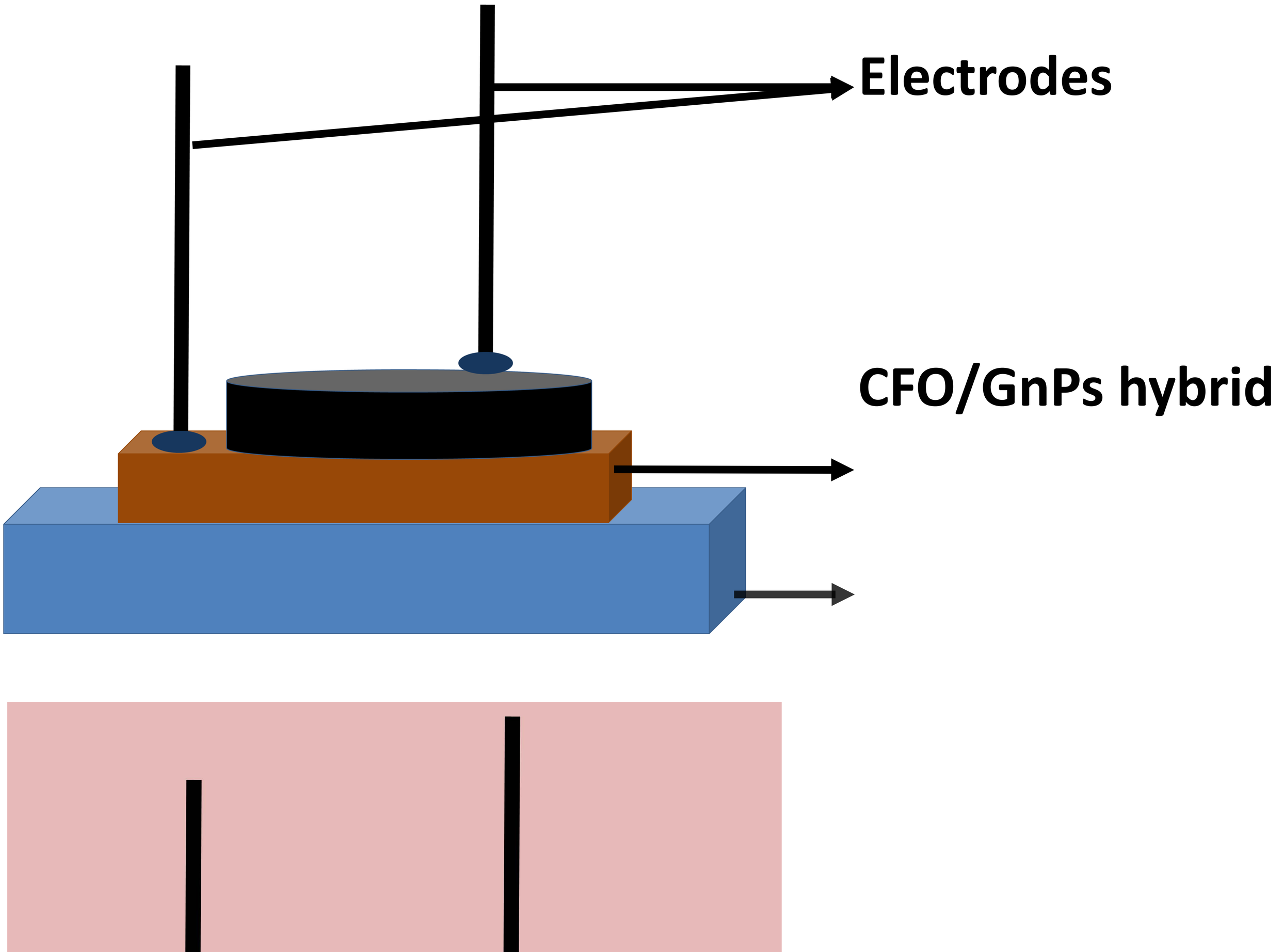


- ➢ Ferromagnetic nature (six line pattern of Mössbauer spectra)
- ➢ Small values of QS illustrate the presence of cubic symmetry
- ➢ The spectrum consists of a normal magnetic sextet due to Fe^{3+} at the tetrahedral (A) sites and another due to Fe^{3+} at octahedral [B] sites.
- ➢ This indicates that the synthesized ferrite is magnetically ordered ferrite at room temperature.

Summary:

- ✓ The XRD spectra reveal the presence of an ortho-ferrite phase at higher Y^{3+} doping.
- ✓ Presence of grain, grain boundary co-contribution and temperature-dependent relaxation was revealed from the frequency dependent complex impedance analysis.
- ✓ Modulus analysis confirmed the hopping mechanism for electrical transport processes in CFLO nanoferrites.
- ✓ The Y^{3+} incorporation enhanced the dielectric constant value in lower frequency region with low dielectric loss suggesting the material favourable to be used in high frequency devices.
- ✓ Substitution of Y^{3+} in the cobalt ferrite structure affects the magnetic properties.

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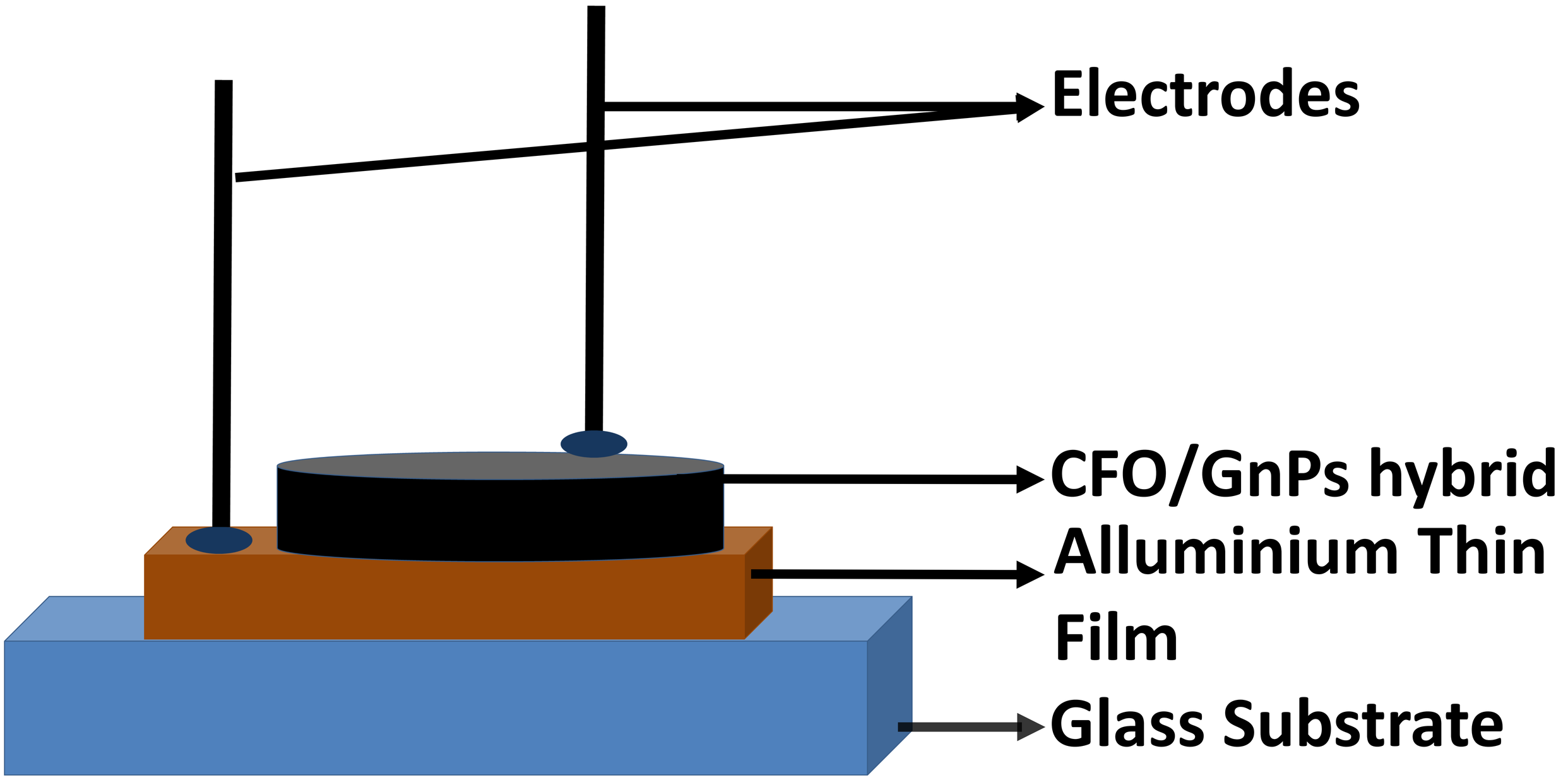
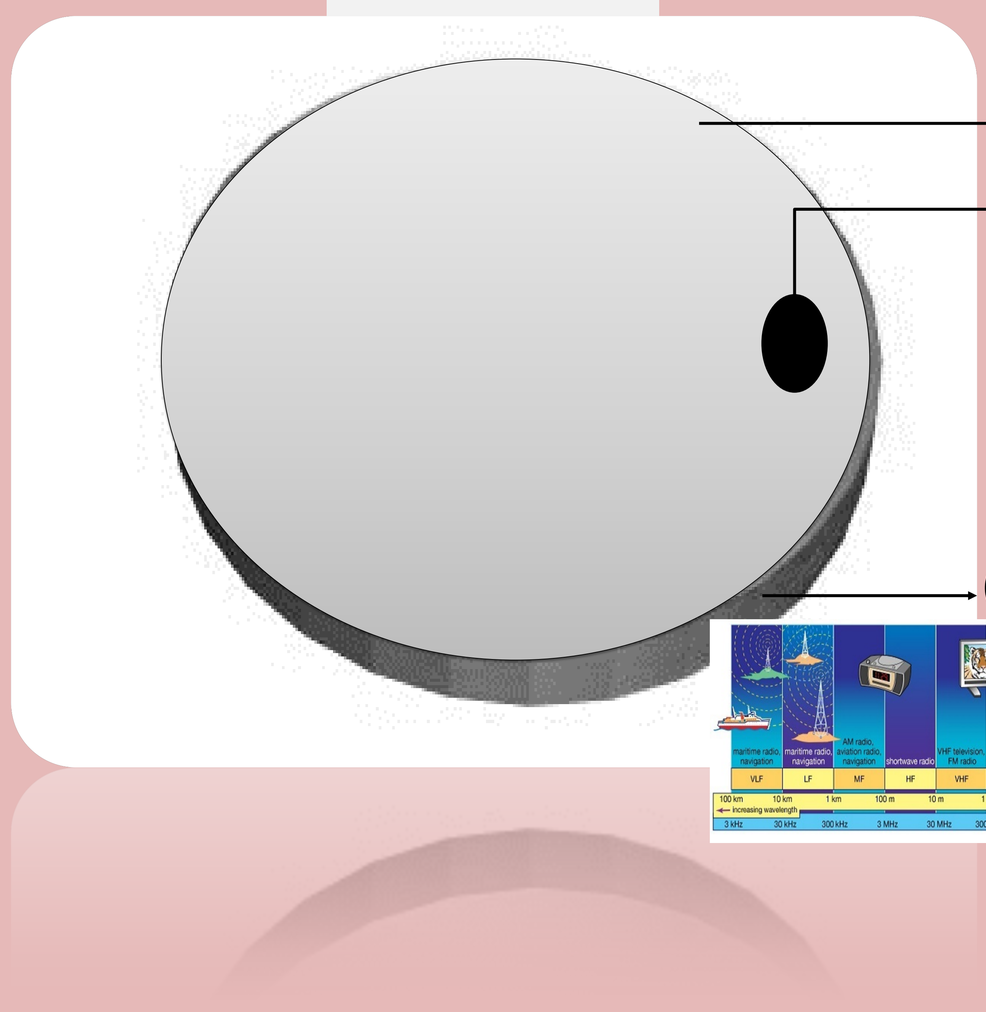
CFO/GnPs hybrid
Alluminium electrode
CFO/GnPs hybrid
Alluminium Thin Film
Glass Substrate


Electrodes
CFO/GnPs hybrid
Alluminium Thin Film
Glass Substrate

Light source



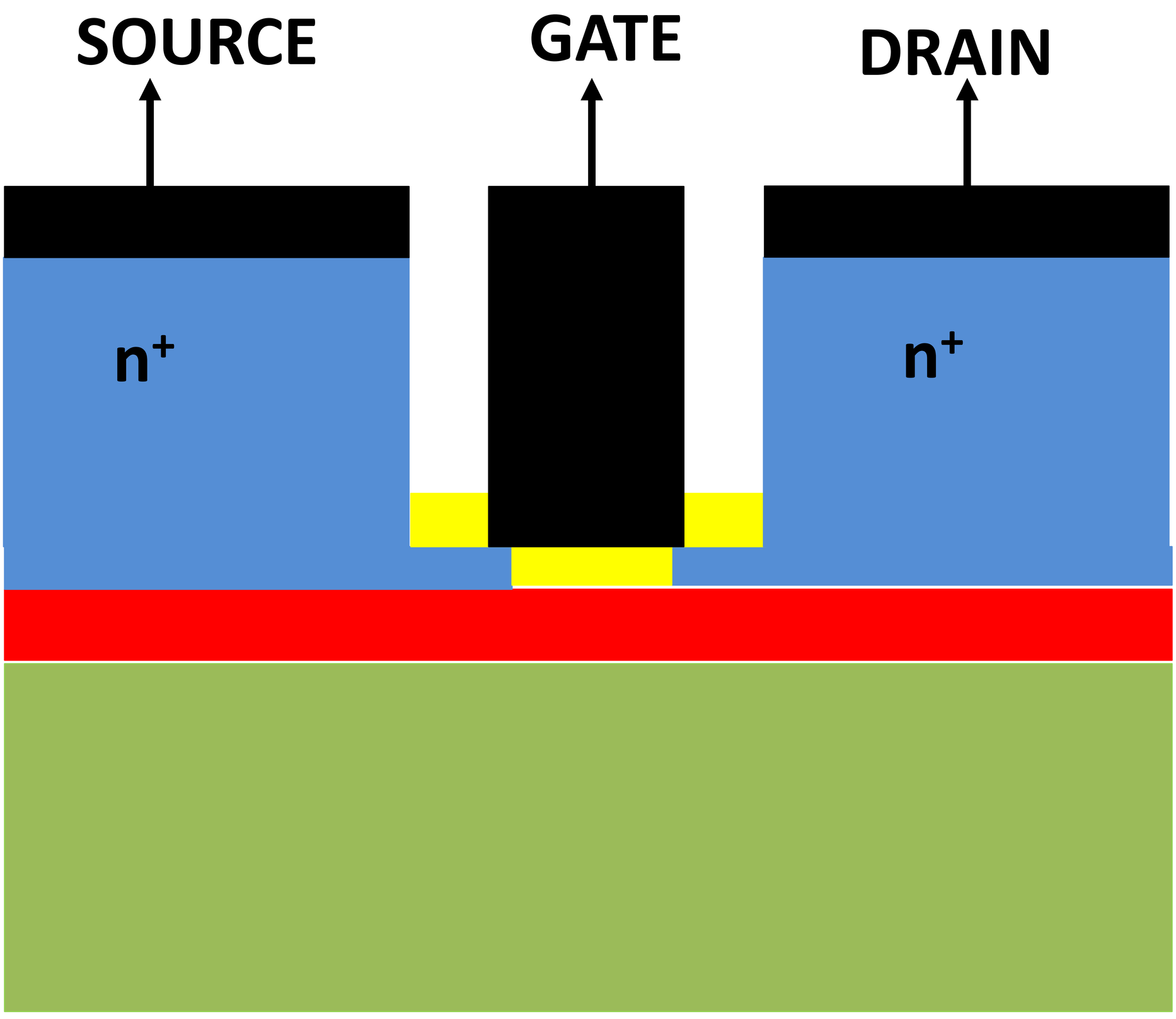
Au electrode

Connecting Wire

Cobalt Ferrite

e

Source: Encyclopaedia Britannica, Inc.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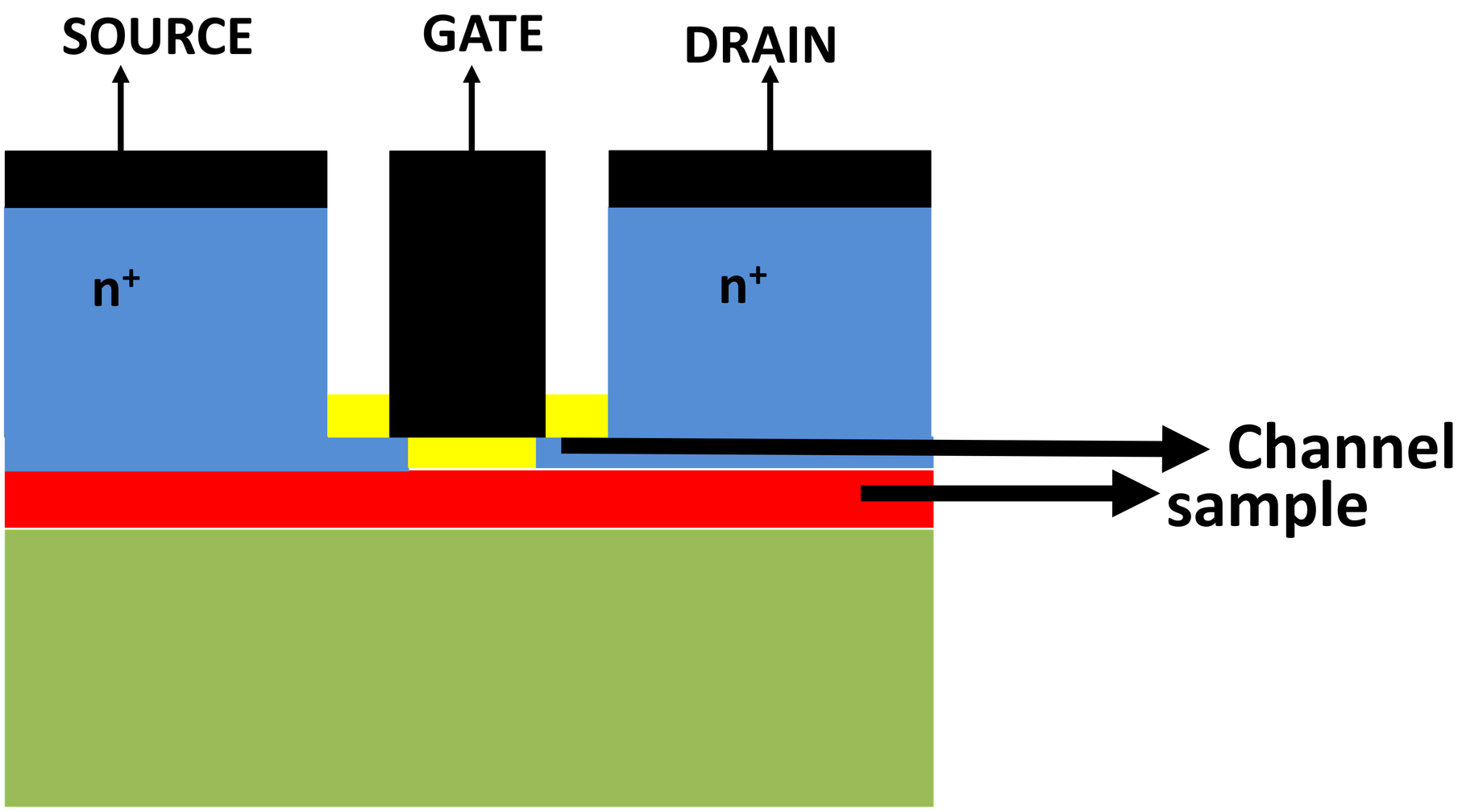
GATE
DRAIN
n+
n+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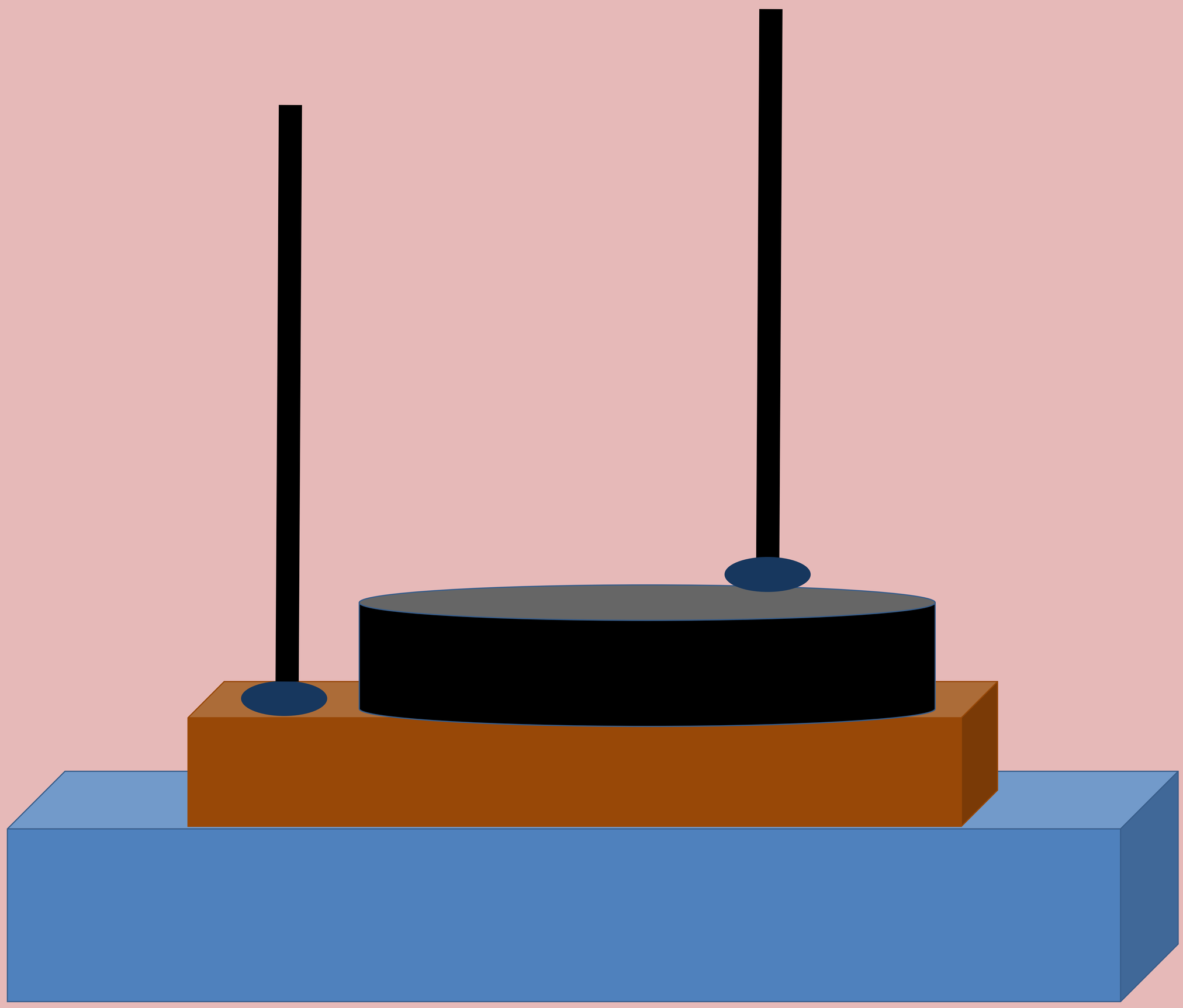
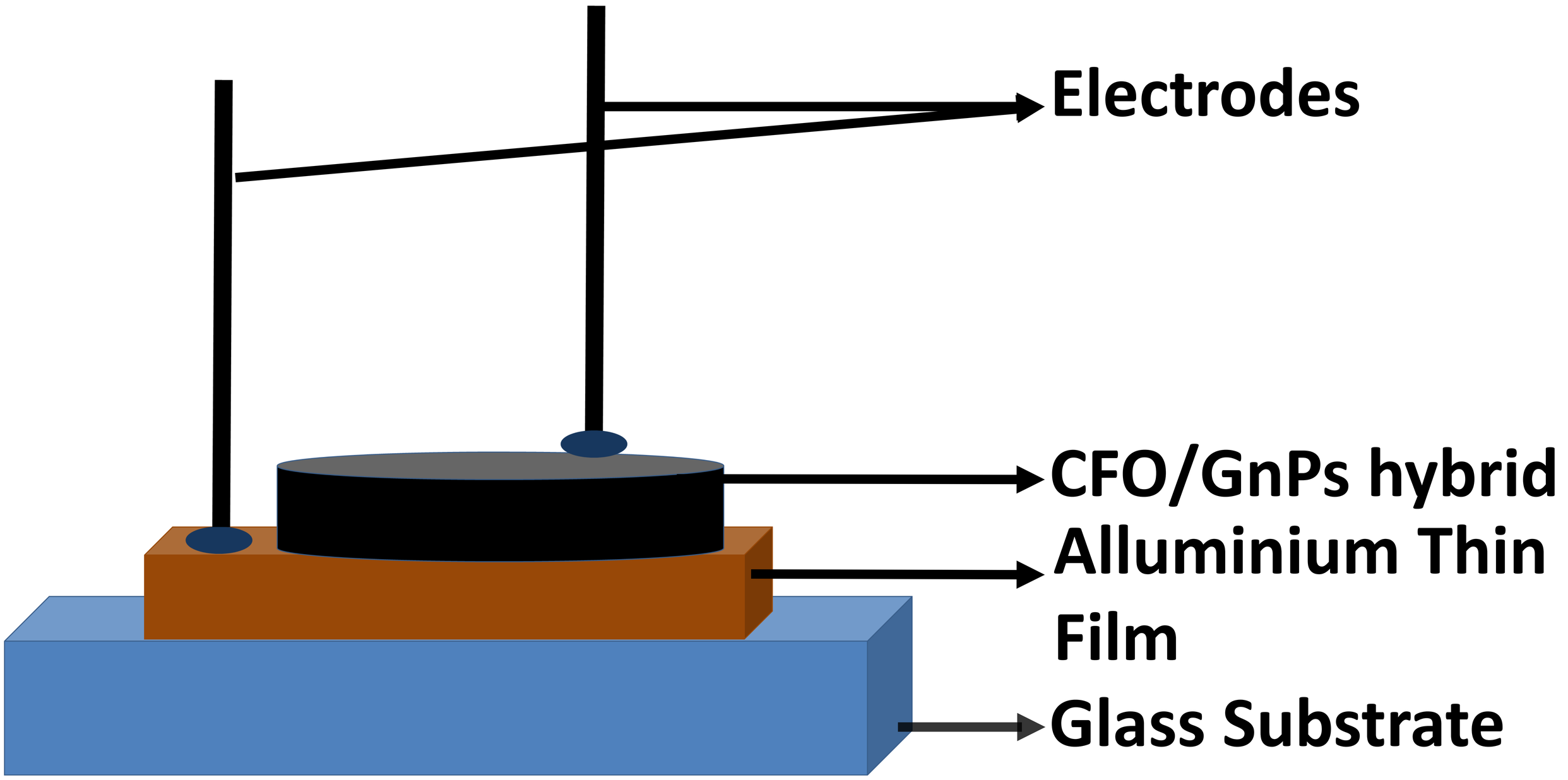
GATE
DRAIN
n+
n+
Channel
sample

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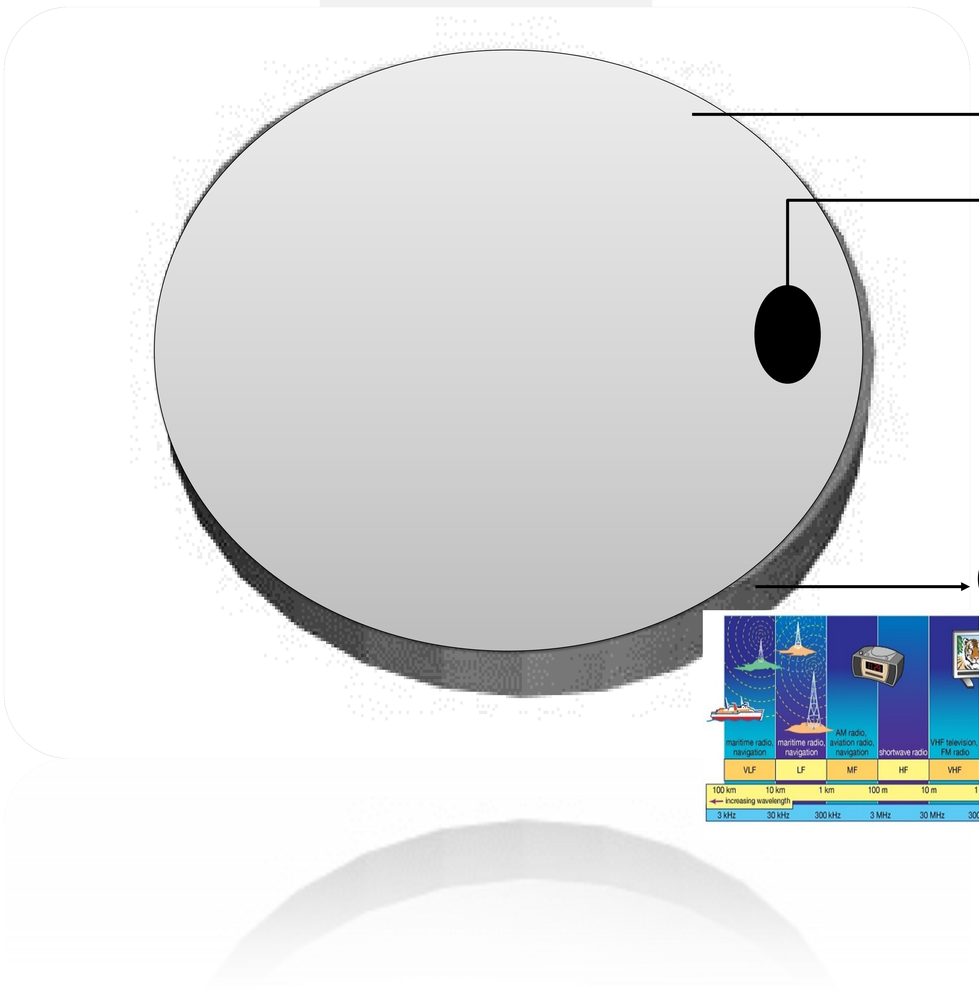

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