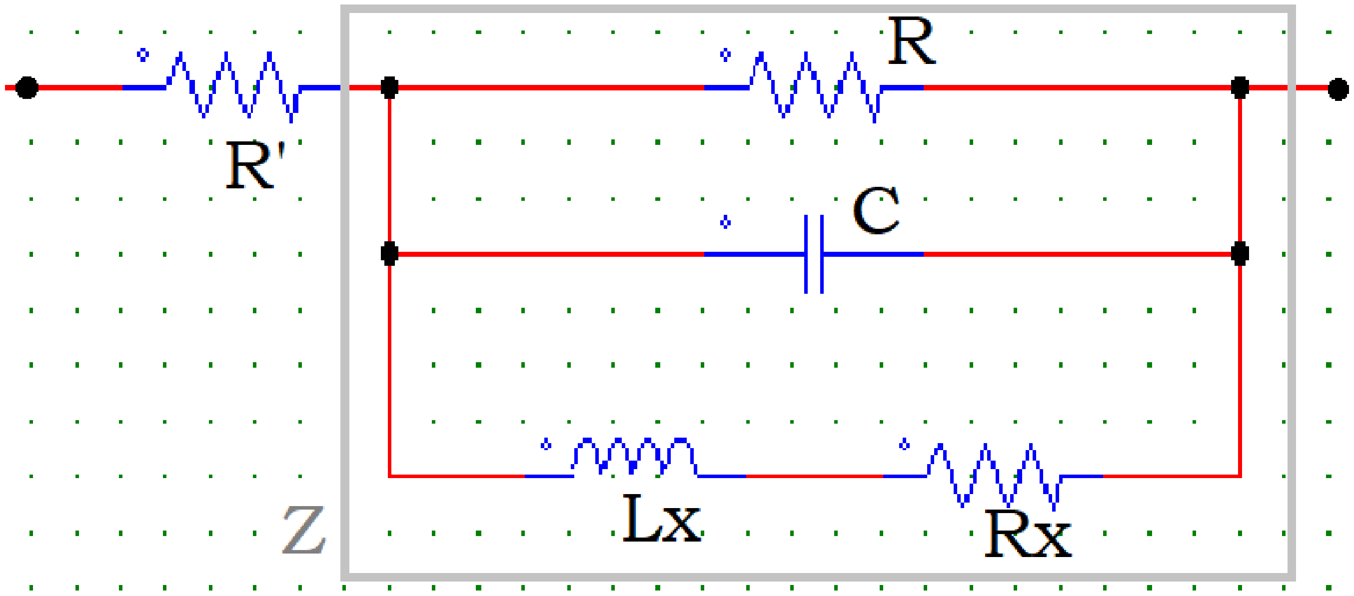
Circuit Designing



- **R’:** serves as the external uncompensated resistance.
- **RC:** accounts for the insulating phase within the film, pointing towards a standard dielectric behaviour.
- The parallel arrangement of the conventional RC and $R_X L_X$ branch suggests a predominantly parallel arrangement of two phases: Insulating and conducting
- **$R_X L_X$:** accounts for the coexistence of insulating areas and conducting domains in the films

Verification of Simulation Model

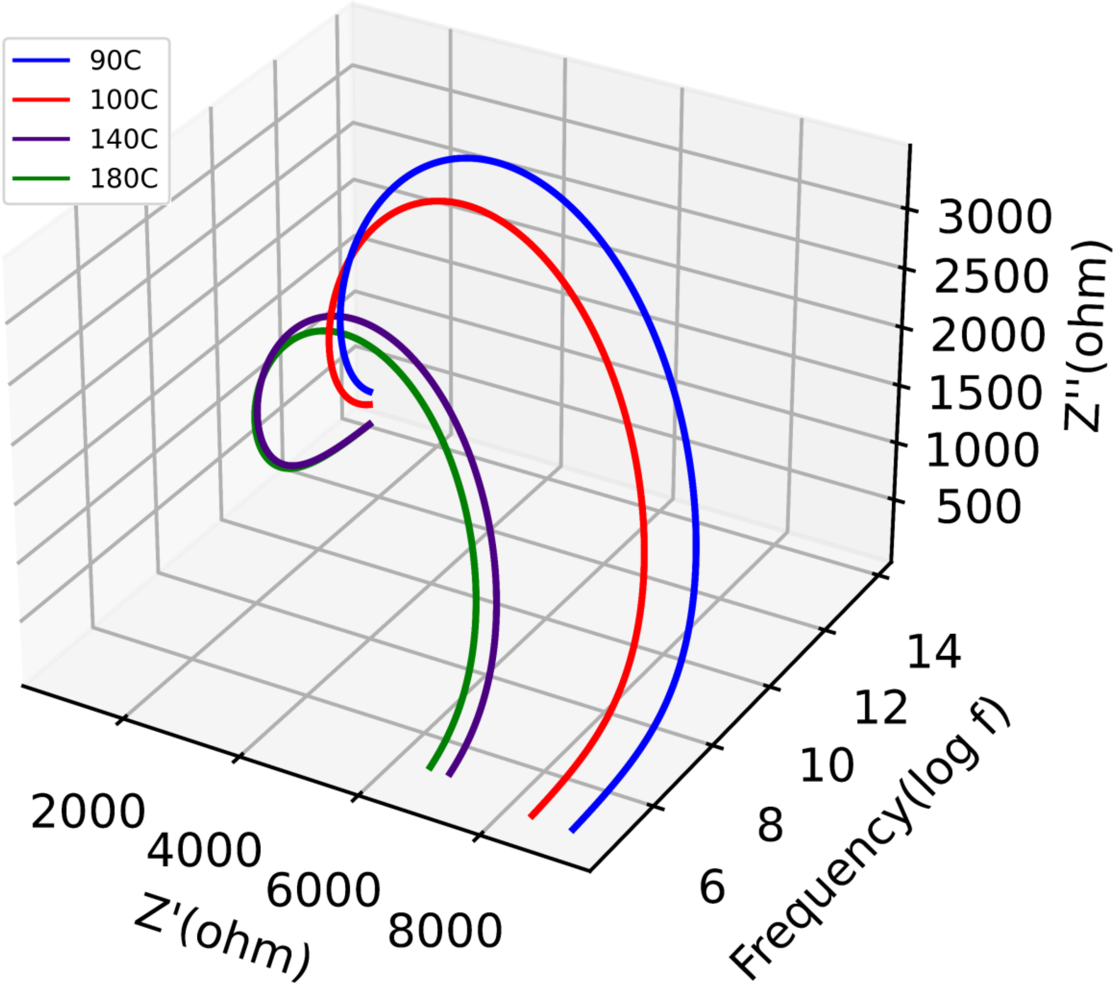


Fig 1: 3d model of impedance spectroscopy of the simulation circuit with varying frequency for different temperatures, for Vanadium Dioxide

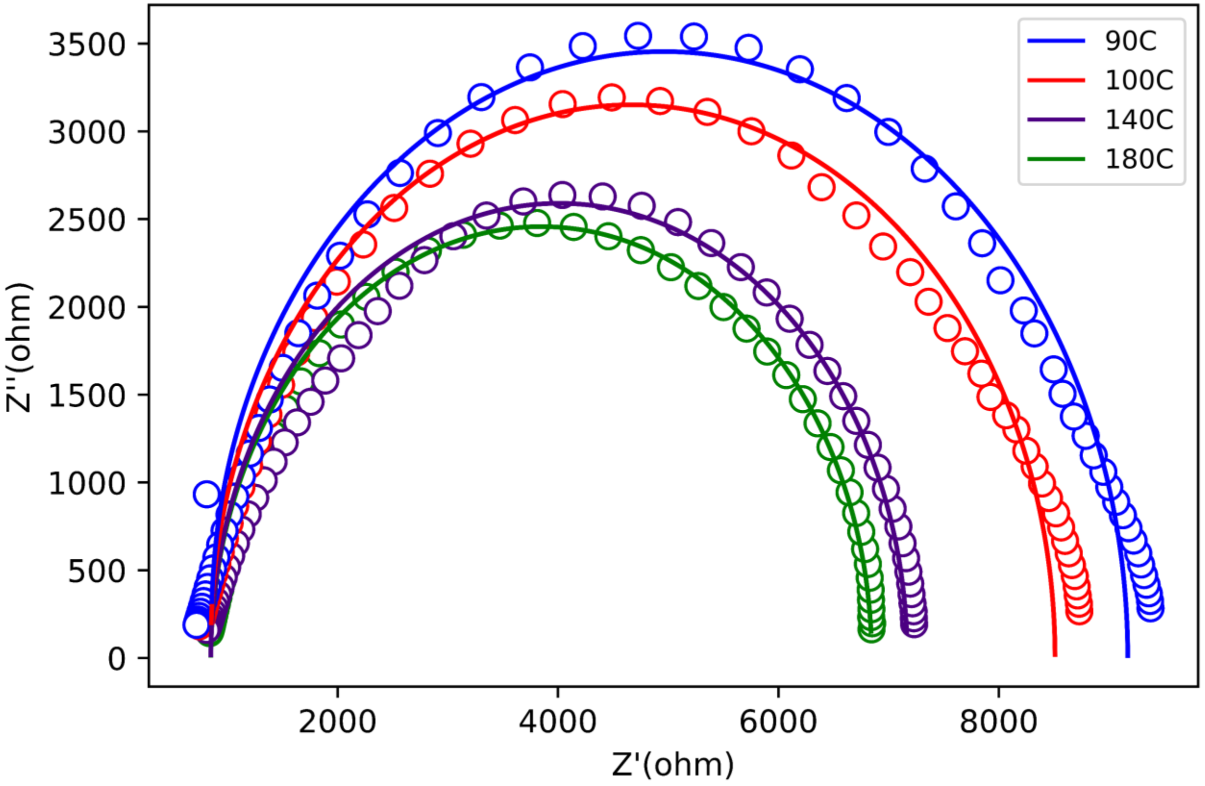


Fig 2: 2d projection of impedance spectroscopy of the simulation circuit on obtained experimental data for different temperatures, for Vanadium Dioxide.

Verification of Simulation Model

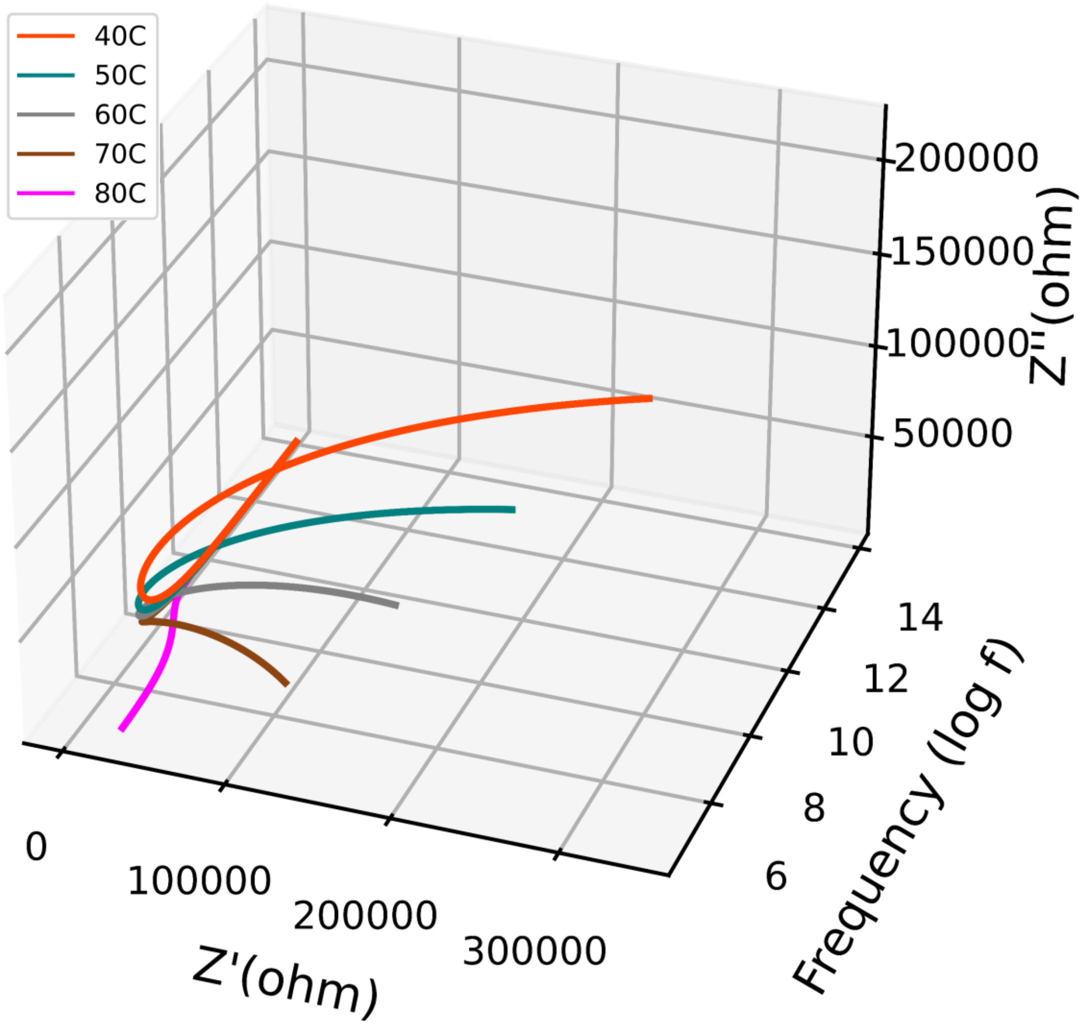


Fig 1: 3d model of impedance spectroscopy of the simulation circuit with varying frequency for different temperatures, for Vanadium Dioxide

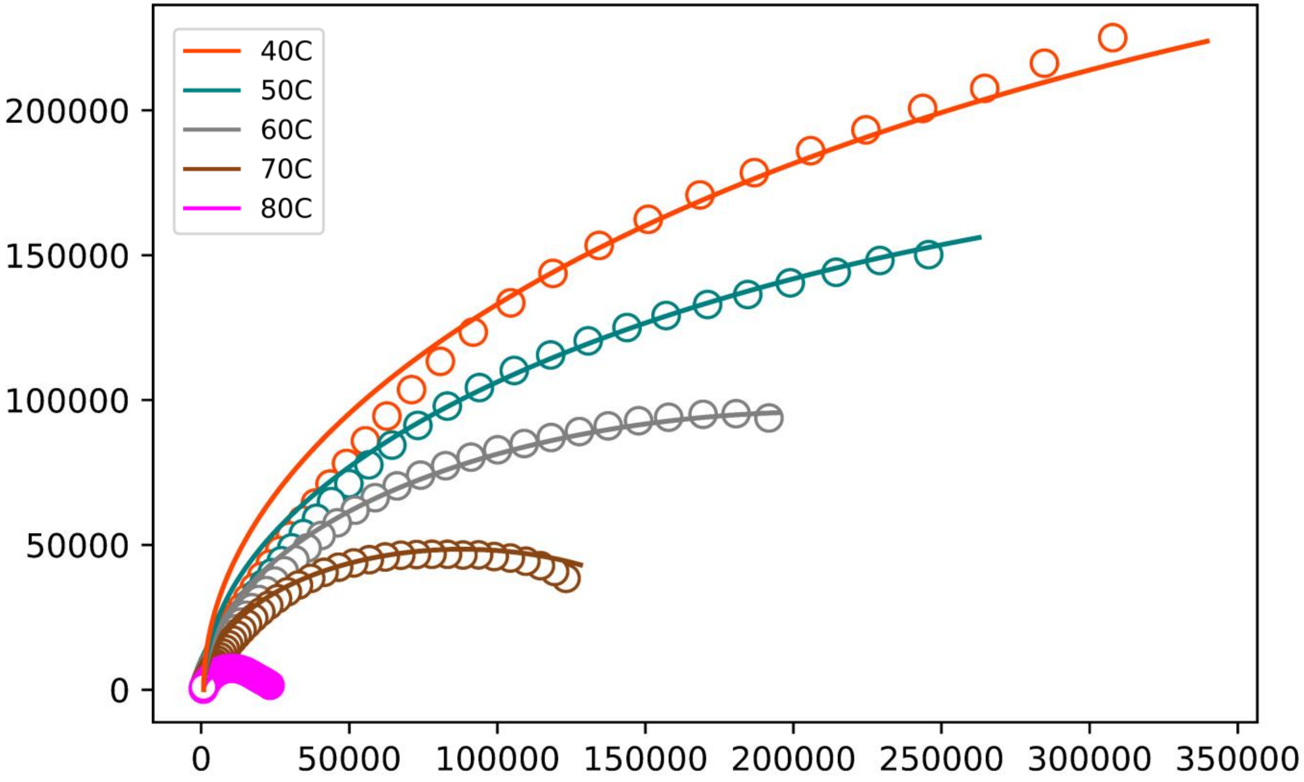
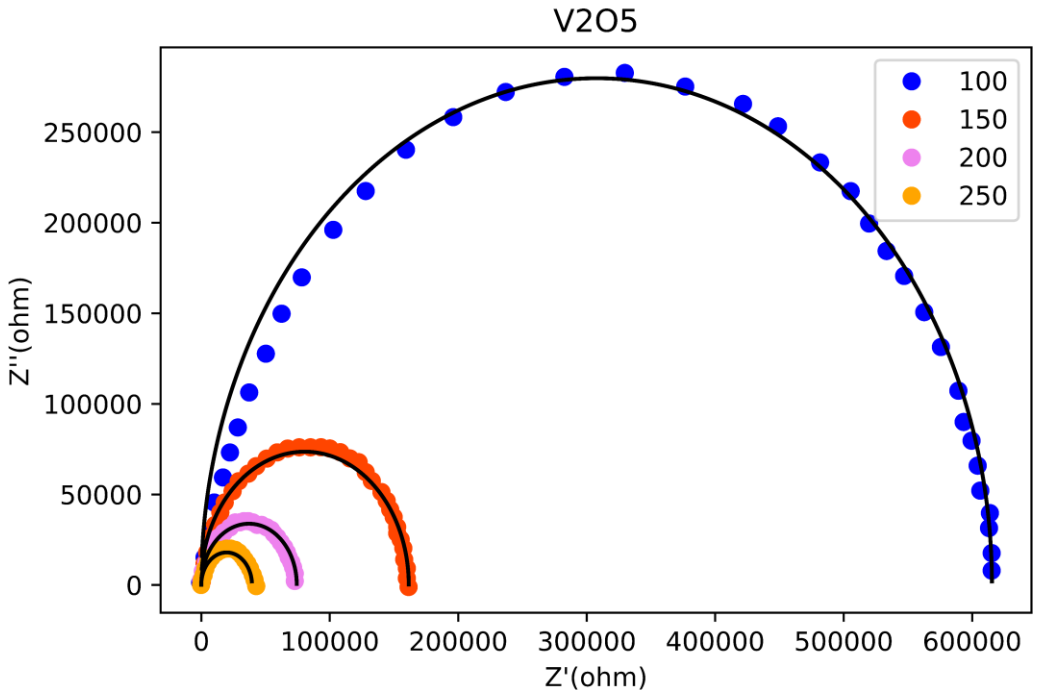
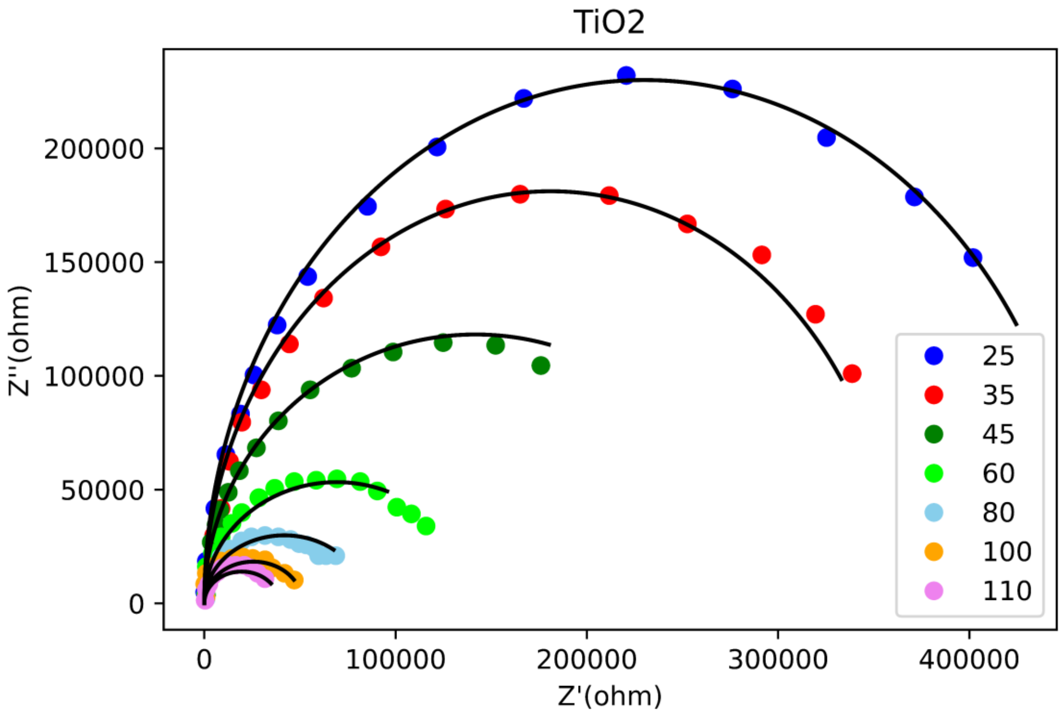


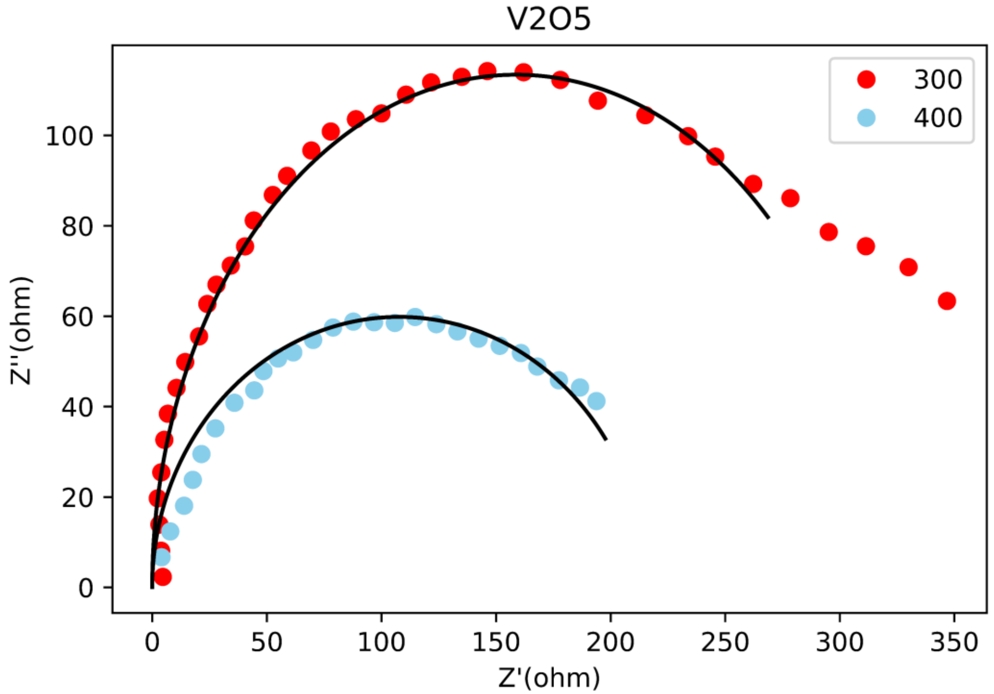
Fig 2: 2d projection of impedance spectroscopy of the simulation circuit on obtained experimental data for different temperatures, for Vanadium Dioxide.

- Conclusion 1 : The simulated data points aligns well with the experimentally obtained data points for the impedance spectroscopy of Vanadium Dioxide. Hence the simulation model can be used to estimate the behaviour of other materials too.

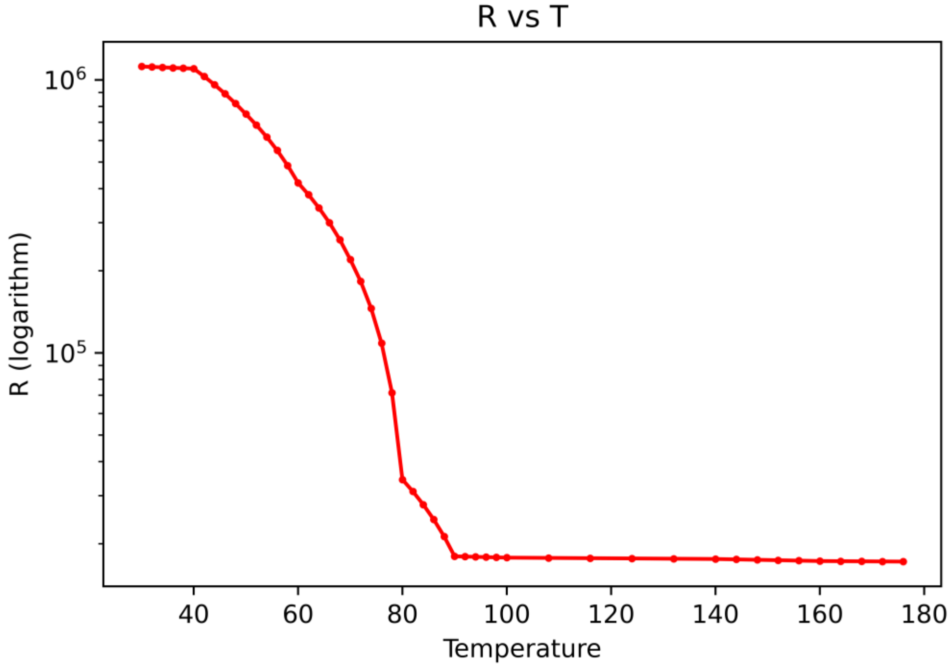
- Extracted data points from different papers was fitted with simulation models to obtain circuital parameters, in similar method as Vanadium Dioxide.

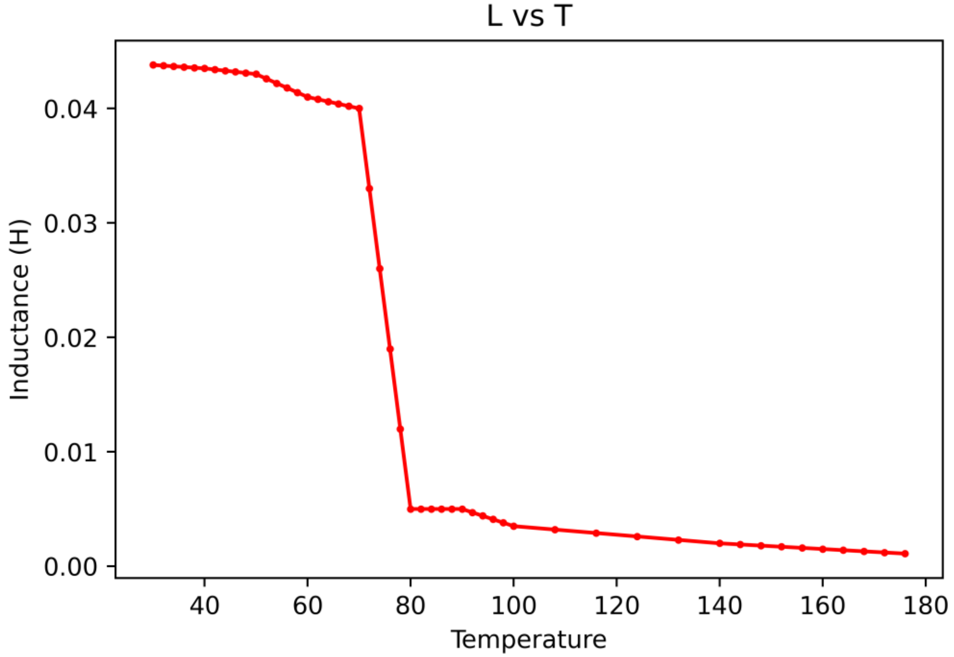


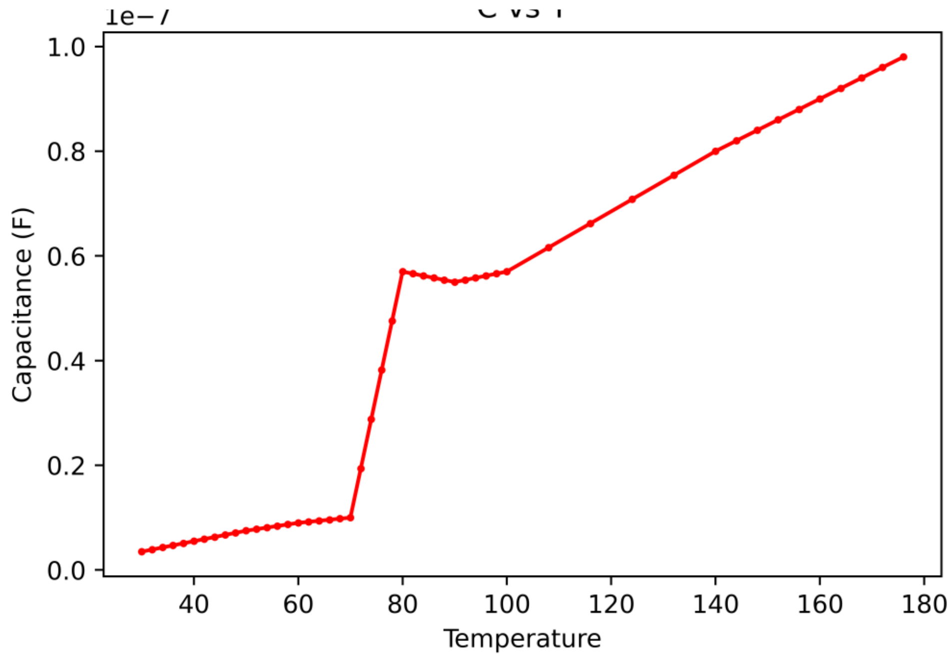




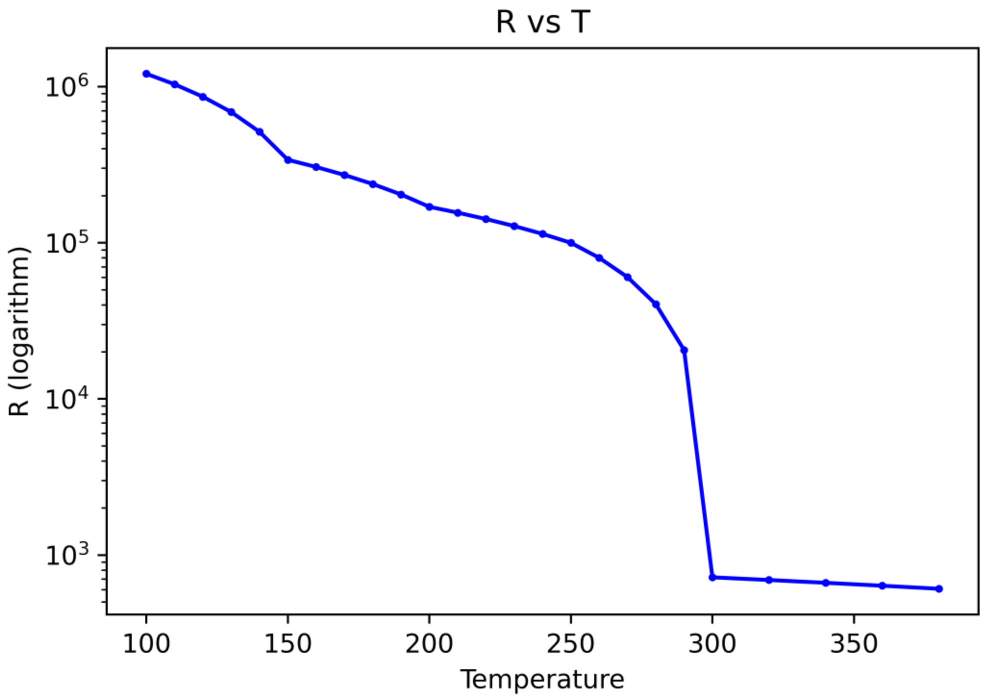
- Variation of circuit parameters for VO2 with changing temperature: MIT is prominent, and is somewhat close to room temeperature (easily achievable)

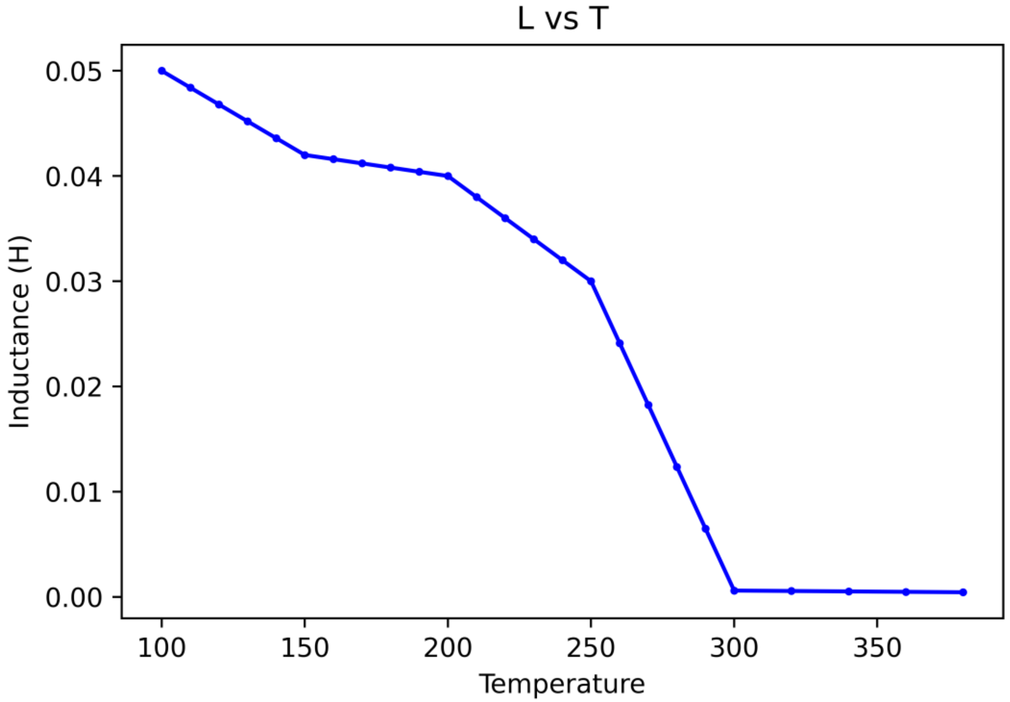


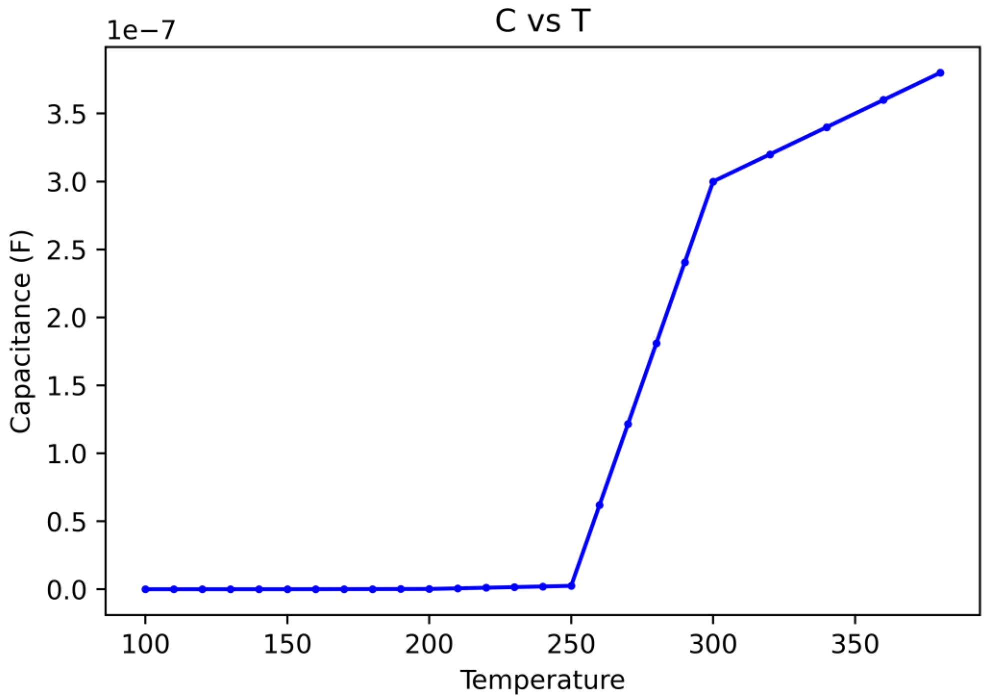




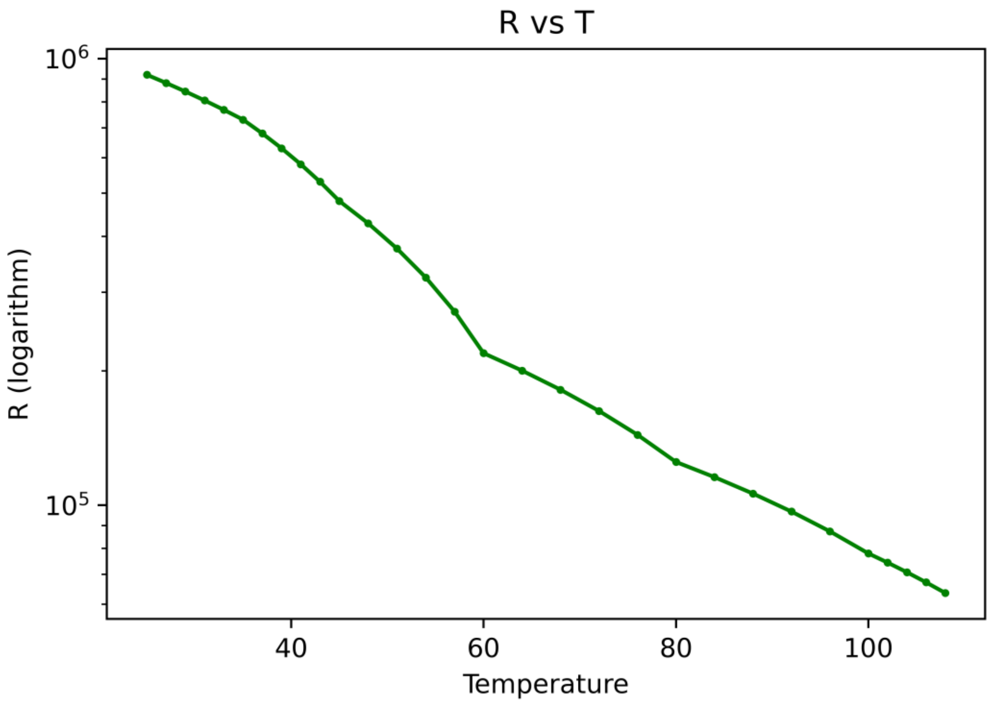
- Variation of circuit parameters for V2O5 with changing temperature: MIT is very prominent, though MIT is much higher than room temperature.

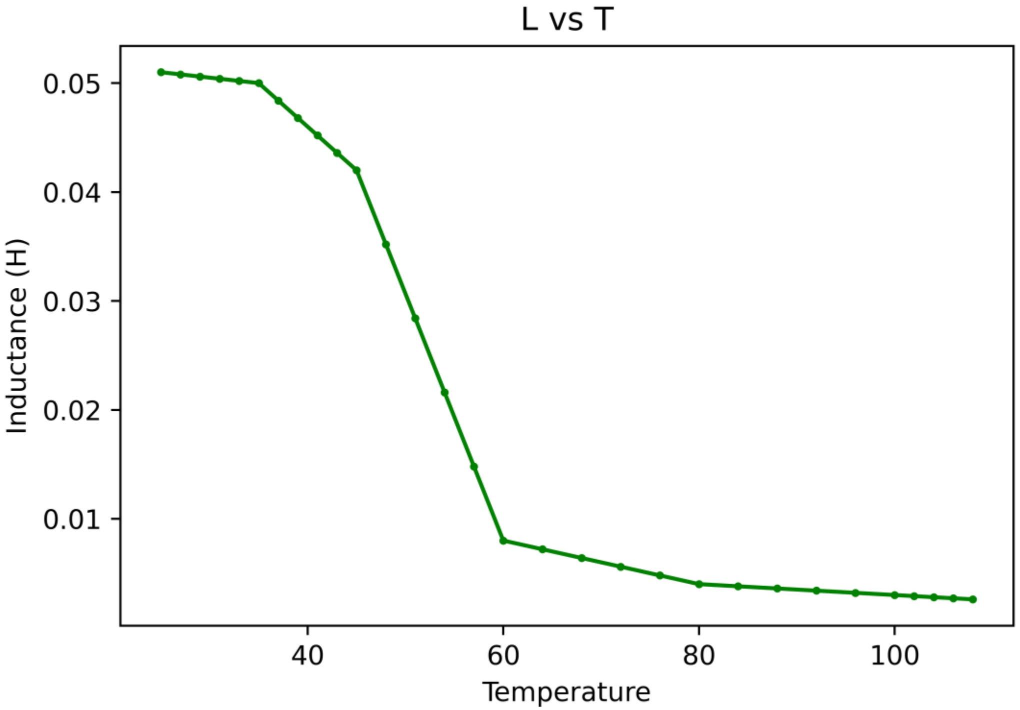


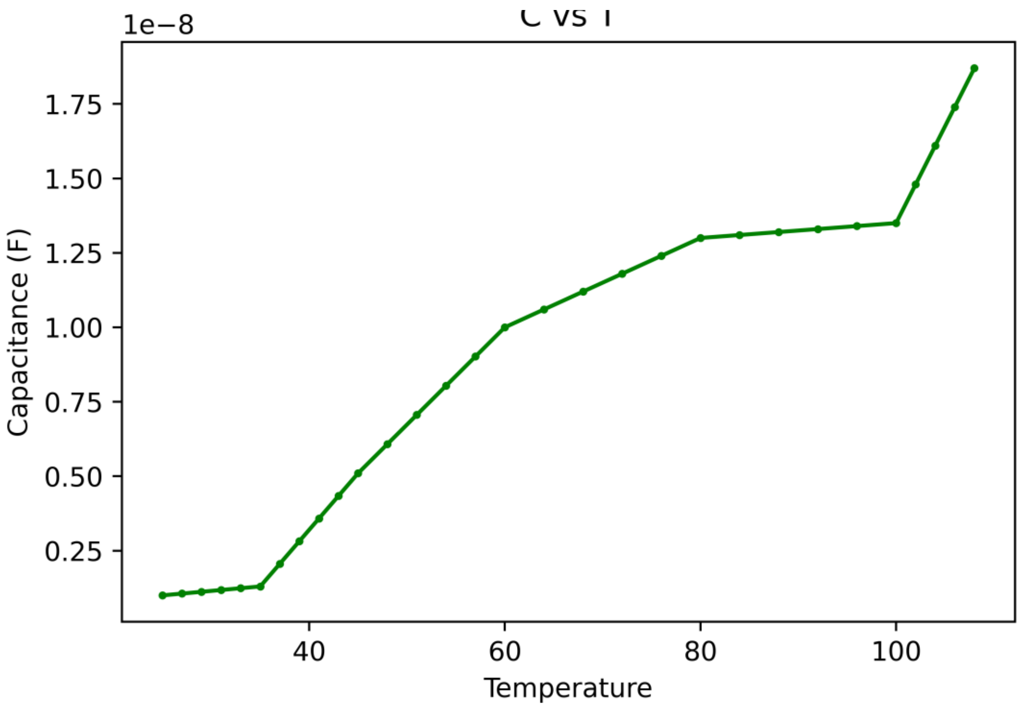




- Variation of circuit parameters for TiO2 with changing temperature: MIT is not very prominent, transition is sluggish





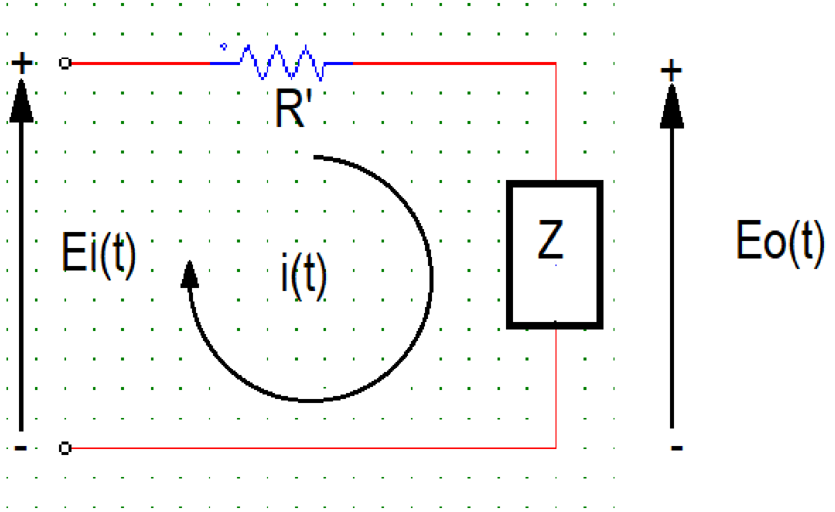


- Conclusion 2 : The simulation obtained MIT of the materials aligns well with the practically obtained MIT as reported by other literature. Hence the combination of circuit parameters obtained for the materials are satisfactory, and can be relied upon to explore further characteristics of the materials by simulation.

Direction and Motivation for next simulation :

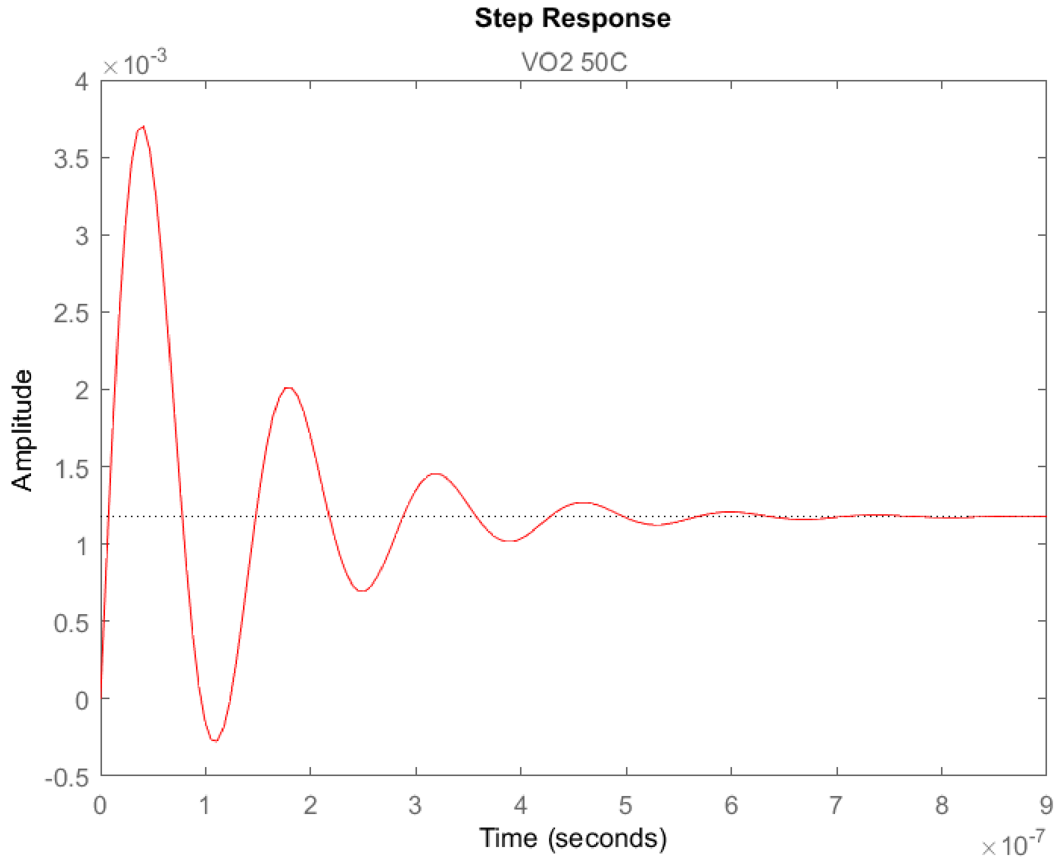
- Step Response of a circuit exposes the circuit behaviour for a specific input.

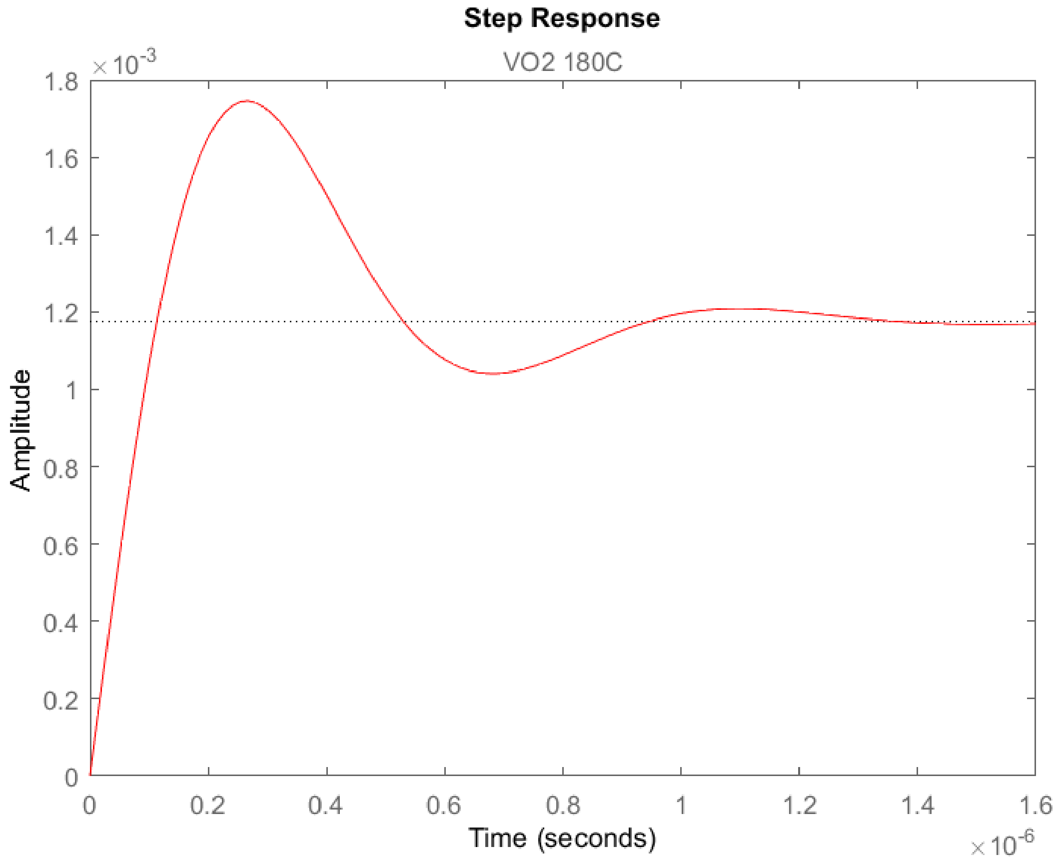
- Here in this case:
  - Input: voltage across R’ and Z: temperature change subjected to the material
  - Output: voltage across Z: competition between kinetic energy and correlation energy of insulating and conducting phases.



- Expectations: The step response should reveal which material gives the fastest and smooth response to temperature variation, and is best suited for electronic devices, like Mott Insulators

Step Response of VO2: Insulating and Conducting phase

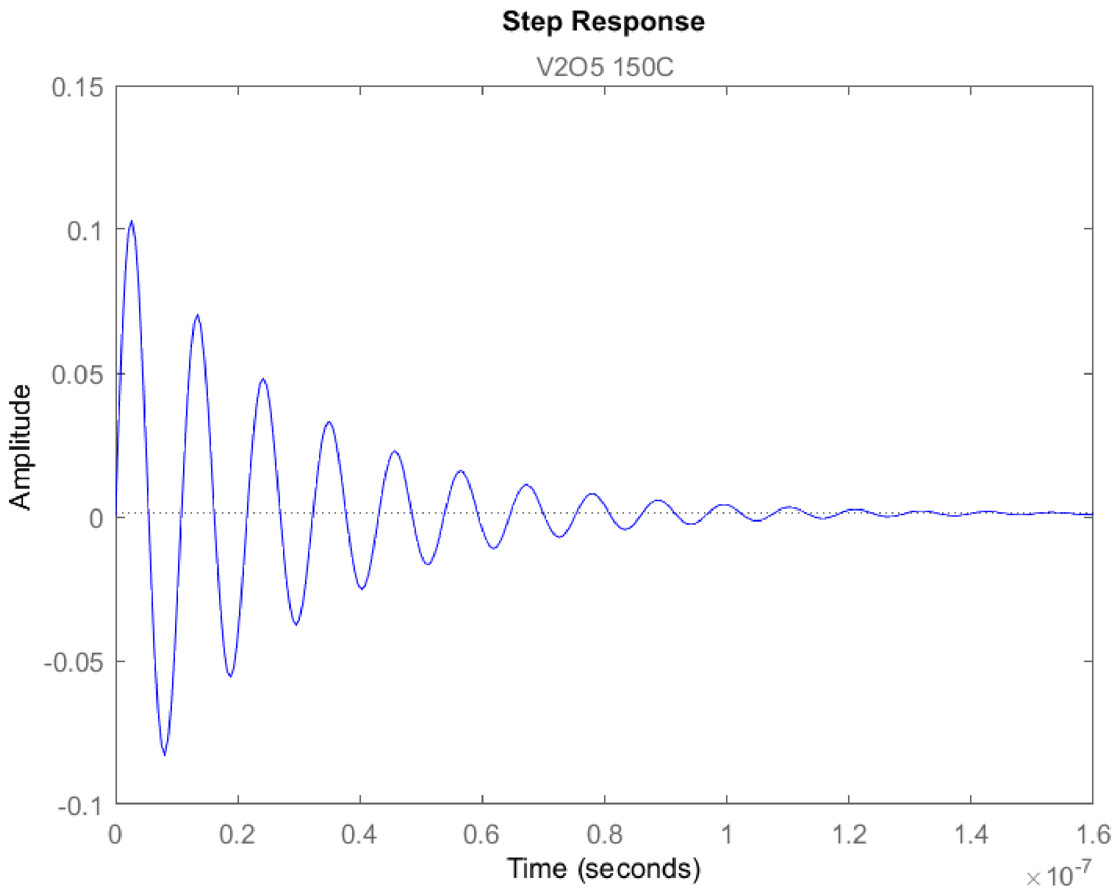


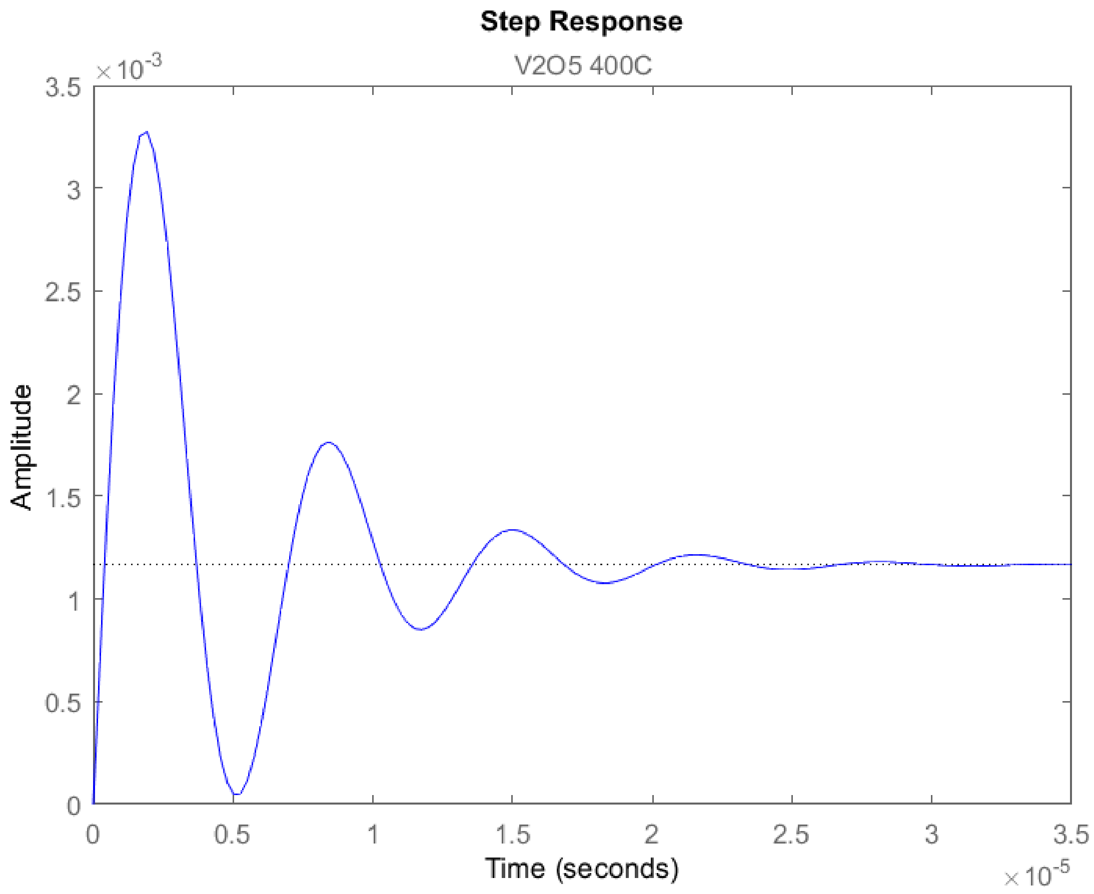


RiseTime: 6.9311e-09
SettlingTime: 8.2047e-07

RiseTime: 1.0118e-07
SettlingTime: 1.7039e-06

Step Response of V2O5: Insulating and Conducting phase

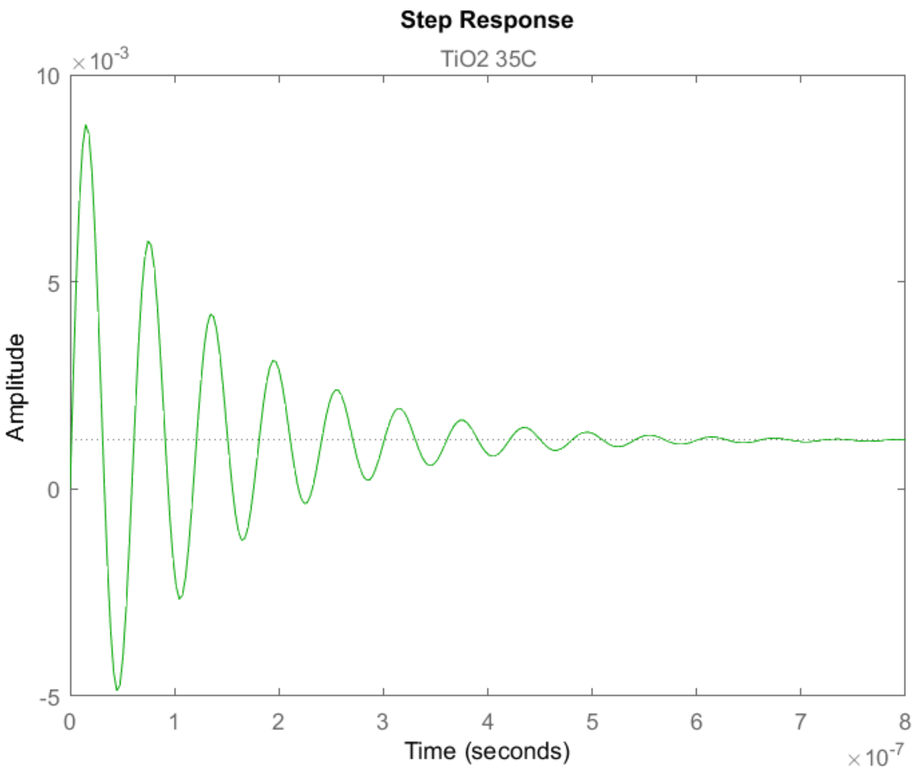


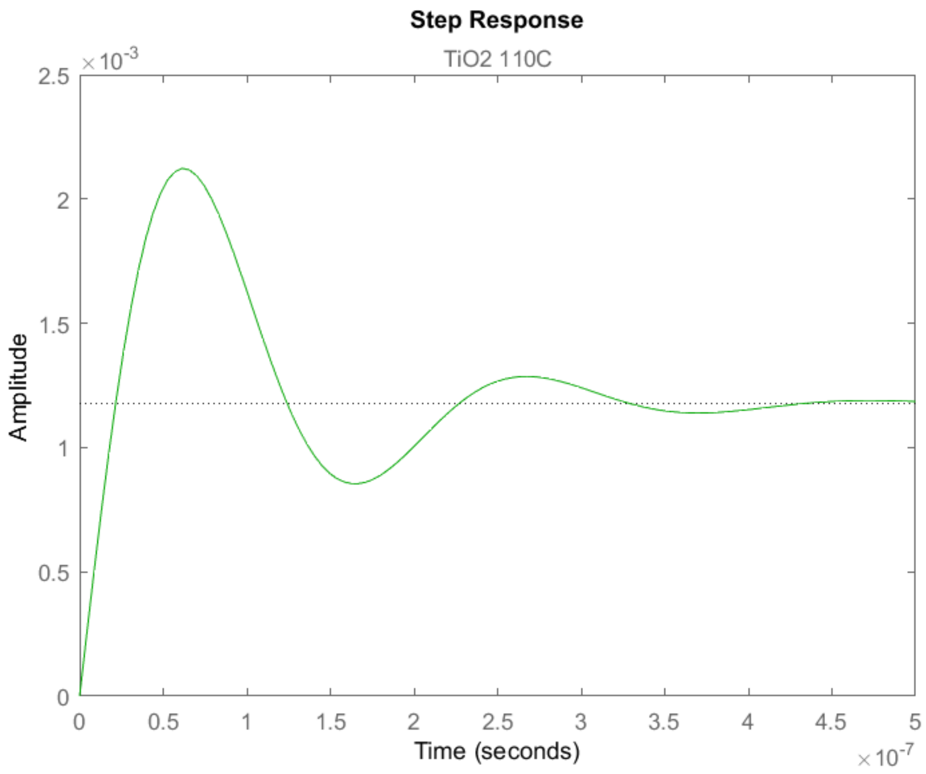


RiseTime: 1.6761e-11
SettlingTime: 1.7532e-07

RiseTime: 3.6842e-07
SettlingTime: 3.2461e-05

Step Response of TiO2: Insulating and Conducting phase

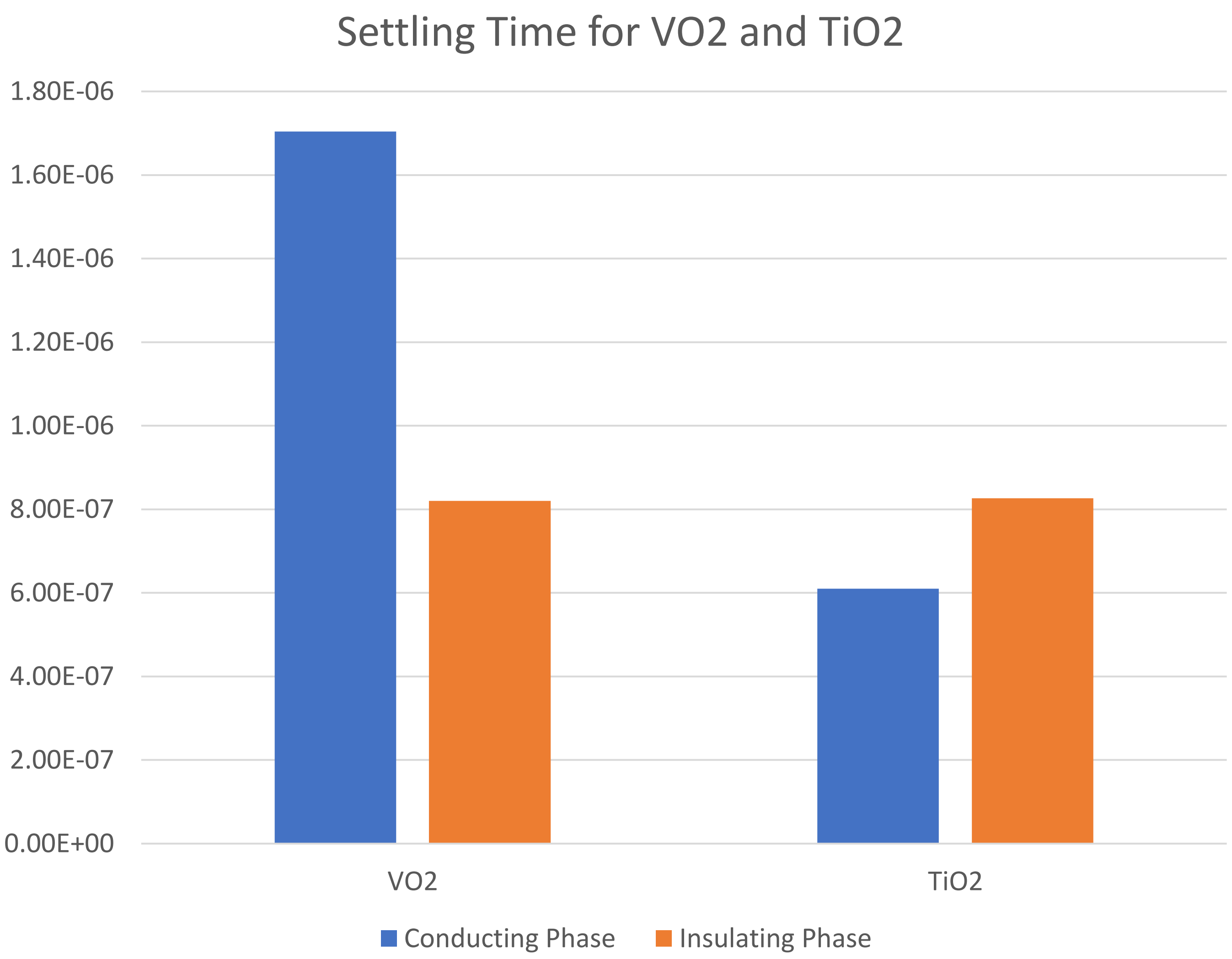


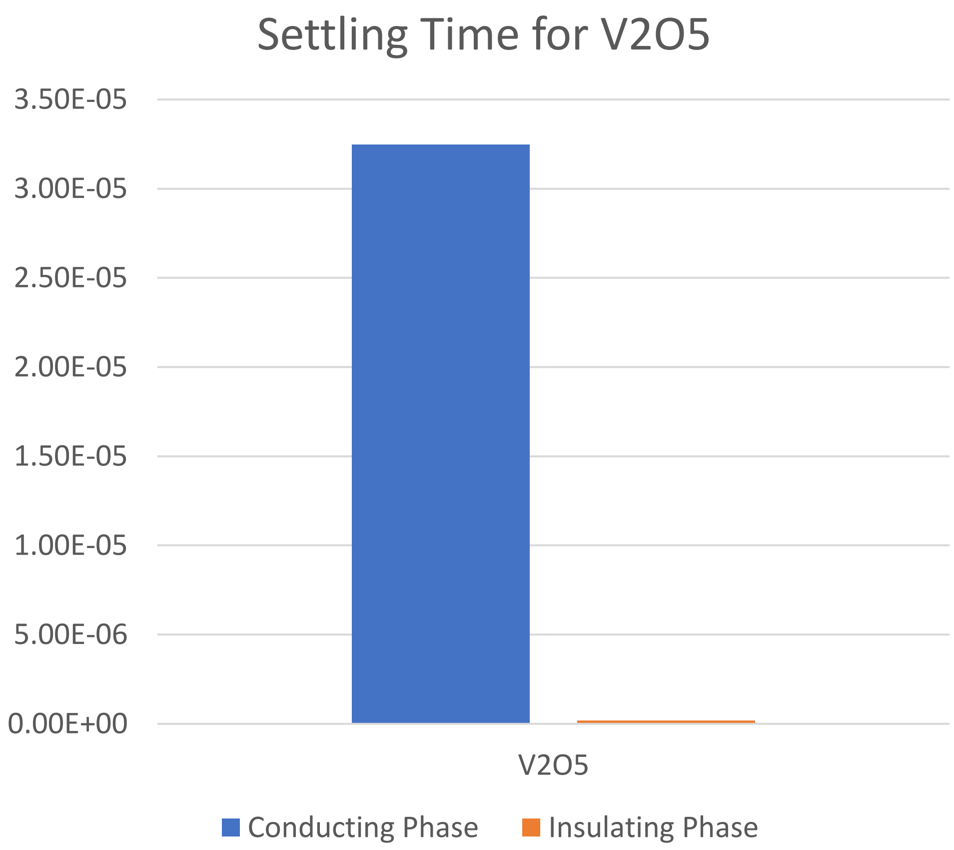


RiseTime: 1.1908e-09
SettlingTime: 8.2634e-07

RiseTime: 1.9339e-08
SettlingTime: 6.1009e-07

Settling Time for different material systems





Conclusion 3 :

- VO2 – System becomes stable faster in conducting phase, and the competition between energies is quite less in conducting phase.
- V2O5 – System becomes stable much faster in conducting phase, and competition between energies is fierce both in conducting and insulating phases, stating materials is prone to become unstable.
- TiO2 – System takes more time to stabilise in conducting phase as compared to its insulating phase, competition between energies is fierce in insulating phase, however is less in conducting phase.
- Inference: VO2 is a suitable material for electronic applications, as system is stale and MIT is near room temeperature. V2O5 can prove to be a promising material if the system can be stabilised, with MIT lowered. TiO2 is shows good response in conducting phase, hence the material is suitable for devices which remains in operating mode for most of the time.