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Mott's Variable Range Hopping Model: an Easy Method for Identification of Phase Transition

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Abstract content
   (Max 300 words)

Thermally induced metal-semiconductor phase transition nano crystalline film of VO2 was synthesized by dipping glass substrate into concentrated solution of NH4VO3 and exposing them to the atmosphere at room temperature for 3 days. At the end of the third day, part of the solution was evaporated and the remaining formed thick film deposit on the substrate. This film was then annealed at 700 degree C in hydrogen environment in a CVD reactor.

Electrical measurement of the annealed film was examined from 24 degree C to 80 degree C for heating cycle and 80 degree C to 24 degree C for cooling cycle. The transition temperature (TC) of VO2 has been reported to be approximately 70 degree C (340K), VO2 as transition metal oxide however exhibit semiconductor properties below TC and metal properties at TC.

Phase transition identification which has been a challenge in the study of poly crystalline material is also addressed in this work, using Mott's variable range hopping model (VRH). Mott in 1974 proposed that charge transport is responsible for electrical conduction as electron hops from one localize state to another; this conduction is mainly due to the thermally-assisted tunneling of the hopped electrons from one state to another within the band-gaps of a material. When temperature is low, the probability that electron thermal activation energy between the states that are close in space but far in energy becomes smaller than that of electron hopping between some more remote states whose energy level happen to be close to each other. In this case, the characteristic hopping length increase with decrease in temperature and thus this hopping theory is referred to as VRH.

In this work Mott's VRH model is used to identify phase transition in VO2 film by fitting the logarithm of the product of conductivity and temperature against the temperature inverse for heating cycle data and cooling cycle data, this result to steps in loop with two separate phases. The first phase, semiconducting (monoclinic, emerges at room 304 K, and this shows that VO2 could exhibit semiconductor properties at room temperature. Other phase is metallic rutile, this emerge at 332K, a temperature which is comparable to the transition temperature of VO2 of 340 K in literature.

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MSc

Main supervisor (name and email)
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