Contribution ID: **323** Type: **not specified**

Effect of neutron irradiation on the structural, electrical and optical properties evolution of RPLD VO₂ films

Vanadium dioxide (VO₂) is explored as an active smart radiation device (SRD) for new type of thermal control material for space craft especially in small satellites such as CubeSats. Current space thermal control systems require heaters with an additional power penalty to maintain moderate spacecraft's temperatures during extreme temperatures. Because its emissivity can be changed without electrical instruments or mechanical part, the use of VO₂ based thin films decreases the request of spacecraft power budget. As an active smart radiator device, an ideal VO₂ based nano-coatings should have a low emissivity at low temperatures to maintain the heat, whereas at high temperatures its emissivity should be high to dissipate the additional unnecessary heat [1,2]. In addition to their active thermal management properties, these VO₂ coatings must exhibit deep space radiations hardness. while in outer space such coatings will be exposed to different cosmic radiation including neutrons. Because these radiations interact with the material in different ways, this contribution reports on the study of VO₂ coatings properties subjected to neutron irradiation with typical energy and doses to space missions. The induced defects on the properties of VO₂ thin films have been investigated using electrical, optical and structural measurements. Both Raman and the grazing incident angle X ray diffraction analysis show that no structural transformation is induced by neutron irradiation, although the grain size formation along the preferential orientation is affected. According to X-ray photoelectron spectroscopy, resistivity and work function measurements, the charge carrier (electron) concentration at room temperature decreases after irradiation. Taking into account that (i) fast neutron irradiation induced defects are mainly a series of Frenkel pairs defects, swelling and disordered regions in VO2 thin films without amorphization and (ii) resistivity and THz transmission measurements confirm that the characteristic semiconductor to metal transition of the VO2 films is preserved upon irradiation, we conclude that VO2 is an excellent candidate for thermal shielding and thermal management of small satellites.

References

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Apply to be
 considered for a student
   award (Yes / No)?

No

Level for award
 (Hons, MSc,
   PhD, N/A)?

N/A

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Session Classification: Poster Session 1

Track Classification: Track B - Nuclear, Particle and Radiation Physics