PROPERTIES OF PULSED LASER DEPOSITED MWCNT/NiO THIN FILMS

B. Yalisi[1, 2], Kittessa Roro[1] , A. Forbes[1, 2]

[1]Council for Scientific and Industrial Research, National Laser Centre, P.O. Box 395, Pretoria 0001, South Africa

[2]School of Physics, University of KwaZulu Natal, Private Bag X54001, Durban 4000, South Africa

Email: byalisi@csir.co.za

Introduction

Pulsed laser deposition (PLD) is a thin-film deposition technique, which uses short and intensive laser pulses to evaporate target material. The technique has been used in this work to produce selective solar absorber (SSA) thin film composites of multiwall carbon nanotubes (MWCNT) and Nickel Oxide (NiO). Whilst most physical vapour deposition techniques require high temperatures to achieve good adhesion between substrate and coating, with PLD it is possible to get excellent adhesion with the substrate temperature set at room temperature.

Selective solar absorbers must have high solar absorptance in the UV-Vis region and a low thermal emittance in the far infra red region to avoid thermal losses. The strength and durability of the thin films are also of critical importance if the coating is to be used in the field, therefore tests have been carried out on samples in the work presented here.

Experimental

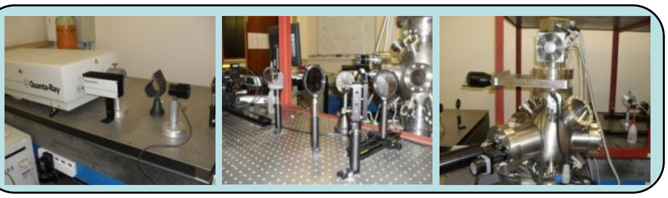


Fig 1: The Nd:YAG laser, optical set up and the PLD chamber used in this study

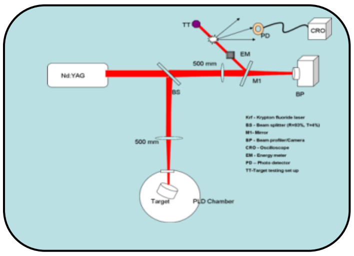


Fig 1 above (from left to right), shows the Nd:YAG laser, the optical set up and the Pulsed Laser Deposition chamber (PLD). Fig 2 shows the schematic diagram of the experimental set up. The Laser used is a Quanta Pro series Nd:YAG, which is capable of delivering four wavelengths: 1064, 532, 355 and currently operating at 266 nm. The energy per pulse for the work reported is 60 mJ and the beam intensity is 2 mJ/cm^2. The repetition rate is 10 Hz.

Fig 2: The experimental set up

Results

Structural

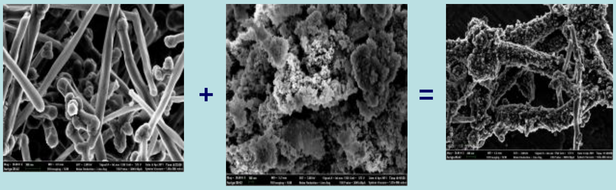


Fig 3: SEM micrographs showing the MWCNTs, NiO powder and the coating of the MWCNTs with NiO in the composite thin film

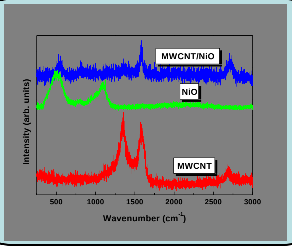


Fig 4:Comparison of the Raman spectra for MWCNT, NiO and the MWCNT/NiO composite

Optical

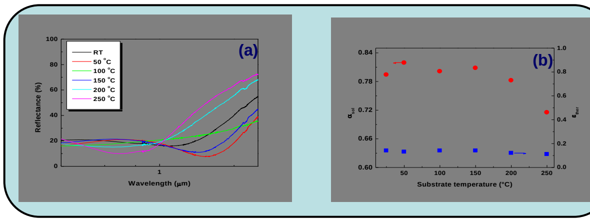
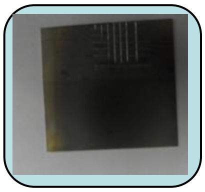


Fig 5: The optical properties of samples prepared with varying substrate temperature

Fig 5a shows the UV-Vis reflectance of the different samples. From the area under the graphs the absorptance was calculated and is shown in Fig 5b. An emissometer was used to measure the thermal emittance of the samples and the results are displayed in the same graph. It can be seen in Fig 5a that there is a shift of the absorptance edge first to the right as the absorptance increases and then to the left as it starts to decrease. This can be a result of substrate temperature causing the thin film thickness to change.

Adhesion



An ISO scratch test was carried out to determine the strength of adhesion of the thin films onto the aluminium substrates. The scratch test measures, on a scale of 0 – 5, how much material has been removed from the substrate. Shown on the left is a picture of a sample that has been scratched. This sample was given a score of 0.5, showing that very little to no material was removed indicating that the PLD technique of depositing SSA material passes this scratch test.

Fig 6: The scratch test

Durability Studies

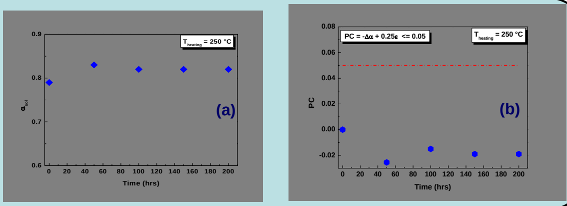


Fig 7: Durability studies

The selective solar absorber coatings are required to work effectively for time periods in excess of 25 years. Therefore, one of the samples underwent the temperature ageing test. Under this test, the sample was put in the oven at 250 ºC for 0, 50, 100, 150 and 200 hours. The absorptance and emittance were measured and recorded at every instance before placing it back in the oven. Fig 7a shows the variation in absorptance with time. The perfomance criterion (PC) was done using the formula shown in fig 7b. The red line shows the limit under which the PC of the sample should fall for it to pass the test. The pictures in fig 8 below confirms visually that the thin films have not been altered at all by the high temperature of the chamber. This can imply that the thin films can be capable of mid to high temperature applications

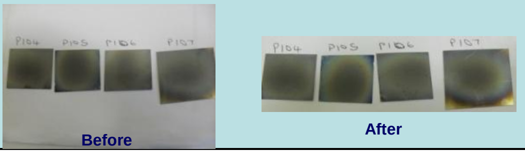


Fig 8: Visuals of the thin film coating

Conclusions

- MWCNT/NiO composite thin films have been successfully fabricated with the PLD technique
- SEM has confirmed that the MWCNT have been decorated with NiO nanoparticles and Raman confirms the formation of a new material with different vibrational properties
- The solar absorptance starts by increasing, gets constant before starting to reduce again
- It has been found that the thin films adhere to the substrate and that the accelerated ageing tests has no significant impact on the optical properties of the thin composite material thin film coating

References

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