PVD coatings for manufacturing of smart glass

Introduction

More than ever renewable energy has become a point of interest in the international community, with many recognising the need to become more reliant on it and to make the move away from more traditional energy sources with greater and greater urgency. One of the big concerns regarding renewable energy in today's age of overpopulation and cramped living, is the space needed to create effective sources, such as wind and solar farms and how realistic they are. One way to increase the energy harvesting is to incorporate transparent solar cells into surfaces of high-rise buildings or window panels in individual homes.

Project Aims/Objectives

- To discover how the thickness of different layers of coatings affected the absorption of non-visible wavelengths (UV and infrared predominantly), while ensuring the final products are still transparent to allow visible light to pass through.
- To achieve the highest combination of transparency and efficiency

Research Methodology

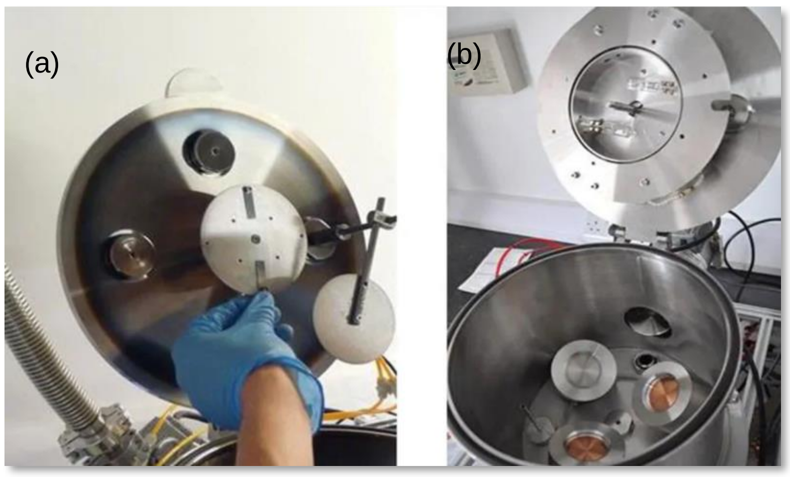
A photovoltaic cell (pv) converts sunlight into electricity using semiconductor materials. These cause electron flow when photons from sunlight are absorbed and cause electrons to be ejected, leaving a hole to be filled by the surrounding electrons, giving the photovoltaic effect. These were the basis of our study. A nanoPVD (nano physical vapour deposition) machine (Fig 1) was used to coat the glass plates with layers of Silver, for electrical conductivity, solar & thermal performance, reflective properties; Molybdenum Oxide, a basic semi conductor, through the absorption would mean the solar to thermal/electricity conversion could be identified; and Vanadium Oxide, once its reached a critical transition temperature of 68 °C becomes an automatic reversible semiconductor-metal phase transition (SMT).These were then sputtered onto the glass plates in various thicknesses using the process detailed below

- The target (the material to be coated with) was placed on the magnetron cathode (Fig 2 (b))
- The substrate (slide to be coated) was placed on the plate at the top of the vacuum chamber (Fig 2 (a))
- A vacuum was formed in a vacuum chamber to reduce gaseous contamination
    - Using two vacuums (turbo molecular and backing pump)
    - A chamber pressure of 10-3 to 10-2 mbar was needed (1013.25 mbar is normal atmospheric pressure at sea level for comparison)
- Sputtering gas was then added to the chamber
    - High molecular weight gas is needed for this process
    - In this study Argon was used
- A cathode was then energized to establish a self-sustaining plasma
    - This was done through a high voltage between cathode and anode causing the surface of the target to be eroded by high-energy ions within the plasma
    - Sputtering gas electrons then accelerated away from the cathode and collide with atoms of sputtering gas, causing electrostatic repulsion, thus "knocking" off electrons from the atoms to create ions
    - These positive atoms accelerated towards negative cathode, causing high energy collisions with the target surface
    - Each collision caused surface atoms to be ejected into vacuum with enough kinetic energy to reach the substrate
    - Due to the higher molecular weight of the argon gas, more collisions took place
    - The liberated atoms produced from these collisions travelled through the vacuum and deposited onto a substrate thus forming a thing film

The produced glass substrates were then to be analyzed using a UV-Vis spectrometer and Scanning Electron Microscope (SEM) with Energy Dispersive X-Ray (EDX) analysis to judge how the intensity of light absorbed by the two semiconductors

Figure 1 – Moorfield nanotechnology nanoPVD

Figure 2 – inside Moorfield nanotechnology nanoPVD. (a) shows the substrate plate and (b)shows the three magnetrons

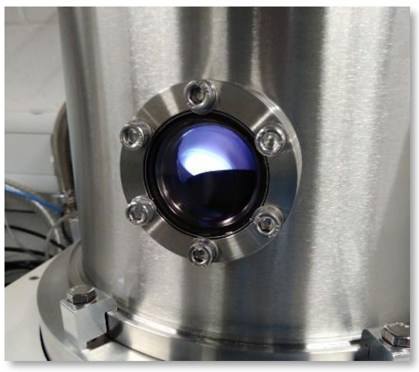


Anticipated outcomes

Due to issues with the nanoPVD, it was impossible to complete the sample synthesis. However, the anticipated outcome were as followed:

- As the layer of the semiconductors increased, the wavelengths absorbed would increase.
- The transparency would largely remain unaffected due to MoO3 and VO2 sputtering largely colourlessly.
- As the layer of silver increased, a higher percentage of wavelength would be absorbed due to the internal reflection of the light.
- This would decrease the transparency and render the produced TPV cells as unusable in the required format.

Figure 2 – nanoPVD machine in the process of sputtering titanium (done as a machine test)



Conclusion and further Recommendations

In conclusion, this is an incredibly important and interesting area of work, due to its relevant applications in the worldwide climate. Unfortunately, due to unavoidable circumstances no results were possible to produce and thus no conclusions can be drawn. For further research it would be advised to continue with this research, but utilize another method of material synthesis.

Acknowledgments

I would like to express my appreciation to the UROS board for the opportunity to complete this project. As well as my sincere gratitude to Dr Ahmed, Dr Nourafkan and Dr Elkin. Their guidance and support has been invaluable and allowed me to perform to my highest potential.

References

[1] M. N. Limited, nanoPVD-S10A, Cheshire : Moorfield Nanotechnology Limited , 2012.
[2] D. J. O'Shaughnessy, Physical Vapor Deposition of, Bethlehem: PPG Industries , 2015 .
[3] H. I. o. Mineralogy, "Molybdite Mineral Data," Hudson Institute of Mineralogy, [Online]. Available: http://www.webmineral.com/data/Molybdite.shtml#.YOv8v-hKg2x.
[4] T. C. X. B. S. e. a. Chang, "Review on thermochromic vanadium dioxide based smart coatings: from lab to commercial application," Advances in Manufacturing, vol. 6, no. 1, pp. 1-19, 2018.
[5] cphnano, "Shimazdu UV-1800," cphnano, 2015. [Online]. Available: https://cphnano.com/shimadzu-uv-1800-uv-vis-spectrophotometer/. [Accessed 7 2021].
[8] N. Hardy, Thin Film Deposition By Sputtering: Essential Basics, Semicore Equipment, Inc, 2013
[9] W. Z. W. H. S. S. M. N. H. S. S. P. Alaa A.F. Husaina, "A review of transparent solar photovoltaic technologies," Renewable and Sustainable Energy Reviews, vol. 94, pp. 779-791, 2018.

Student: Melanie Randall-Evans

Supervisor: Dr Waqar Ahmed

University of Lincoln
Lincoln Academy of Learning and Teaching

Undergraduate Research Opportunities Scheme

DISCOVER_
LNCN.AC/UROS
@UOL_LALT
#UROS2021