SEMICONDUCTOR SELECTIVE COATINGS AND THEIR APPLICATIONS IN CYLINDRICAL SOLAR COLLECTORS OPERATING UNDER CONCENTRATED FLUX

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DEPARTMENT OF PHYSICS

Thesis submitted
in fulfilment of the requirements
of the degree of
DOCTOR OF PHILOSOPHY

to the
INDIAN INSTITUTE OF TECHNOLOGY, DELHI
1983

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ACKNOWLEDGEMENTS

It is with great pleasure I express my deep feelings of gratitude to Dr. H.K. Sehgal, for his continuous supervision and personal interest throughout the progress of the investigations. For the encouragement and help given by him in overcoming seemingly unsurmountable problems during this project, any compliment to him is inadequate.

I take this opportunity to extend my thanks to Prof. K.L. Chopra and Prof. O.P. Agnihotri for providing necessary facilities for various measurements in their laboratories. Thanks are also due to Dr. A. Banerjee, Dr. R. Gopalan and Dr. S.R. Das for their help in AES study of the selective coatings and to Dr. V. Dutta for his help in Hall coefficient measurements. I am extremely thankful to Prof. S.S. Mathur, Head, Centre of Energy Studies, for the provision of necessary facilities for the work reported in Chapter VI and to Dr. N.K. Bansal for his helpfull discussions during the theoretical work reported in Chapter V. Above all, I am grateful to Prof. B.B. Tripathy, Head, Department of Physics, for his constant encouragement during the progress of the investigations.

I offer my sincere thanks to my colleagues, Mr. M. Madhusudan, Mr. Mukesh Jain and Mr. Subodh Kumar, who helped me at various occasions during the investigations.

My thanks are also due to my friends, Dr. Usha Singh, Miss Navdeep Gill and Mrs. Madhuri Sachan for their help, cooperation and moral support during the progress of the project.

I express my appreciation for Mr. S.L. Aneja for his flawless and neat typing. My thanks are also due to Mr. N.S. Gupta and Mr. S.S. Singh who made excellent figures with great patience and to Mr. Amar Singh for his neat and efficient cyclostyling.

I would also like to acknowledge the Indian Institute of Technology, Delhi and the Council of Scientific and Industrial Research, New Delhi, for the financial help during this project.

I do not have words to express my gratitude to my respected father and brothers and sister for their unstinted cooperation and moral encouragement in the persuit of my work.

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ABSTRACT

The objective of the work was centered around the development and characterization of low cost selective absorber and heat mirror coatings, and optimization of tubular collector and concentrator systems for their use in photo-thermal conversion of solar energy. The experimental and the theoretical investigations that have been carried out are summarized below.

Selective absorber coatings of cobalt oxide (for high temperature applications) and cobalt oxide-cobalt sulphide (for low temperature applications) have been grown on commercial aluminium and galvanized iron substrates by a low cost method of spray pyrolysis. Optimum conditions of growth have been worked out by a comparative photo-thermal analysis of the coatings under identical optical illumination. Effect of growth conditions and film thickness on the absorptance and emittance have been studied. Determination of absorptance has been done by a Willey Alphameter whereas emittance of the films at different temperatures have been measured by the heat balance technique. Scanning electron microsoope and electron diffraction studies have been performed to obtain information about surface topography and structural composition of the films. Biangular and angular reflectivity measurements have been carried out to study the dependence of reflectance (absorptance) of the films on the angle of incidence of solar light. Thermal stability of the films heat treated at different

temperatures under different atmospheric conditions has been investigated by scanning electron microscope study, absorptance and emittance measurements and Auger depth profile analysis.

Heat mirror coatings of tin oxide, Sb-doped tin oxide (SnO_2:Sb) and Sn-doped indium oxide (In_2O_3:Sn) have been grown on the inner walls of one meter long glass tubes by the CVD technique. The films have been investigated for their surface topography, structural composition, transmittance in the solar spectral range, reflectance in the thermal infrared, electrical conductivity, charge carrier concentration and mobility.

A comparative photo-thermal analysis has been carried out under identical optical illumination to work out the optimum gap width between the tubular absorber and the concentric glass envelope in tubular collectors employing cobalt oxide selective absorber and operating under non-evacuated conditions. Effects of variation in the gap width with the diameter of the absorber tube and the order of vacuum in the annulus on the photo-thermal performance of the collector have been studied. Effects of gap width, order of vacuum and incident illumination on the heat losses have been worked out theoretically for stagnant/transient operations of the collectors.

A Fresnel reflecting concentrator has been fabricated

using 85 mirror strips of ~ 23 mm width for the central 41 mirrors and ~ 20 mm width for the outer ones. In the design, the spacings between the mirrors in the two regions have been adjusted so as to avoid shadowing and blocking by the adjacent mirrors. Effect of number of mirror strips and concentrator to receiver separation on the concentrated power reaching the receiver has been investigated both experimentally and theoretically.

Photo-thermal performance for zero power output (i.e. under no flow condition) of the optimized tubular collector employing cobalt oxide selective absorber with- and without- heat mirror coated concentric glass envelope has been investigated under nonevacuated and evacuated conditions of the collector operating in conjunction with the optimized concentrator.

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