SPECTRALLY SELECTIVE BLACK COBALT COATINGS

BY

K. CHIDAMBARAM

DEPARTMENT OF PHYSICS

Thesis submitted
in fullfilment of the requrements
of the degree of
DOCTOR OF PHILOSOPHY

to the

INDIAN INSTITUTE OF TECHNOLOGY, DELHI

AUGUST, 1982

THESIS SUPERVISORS

PROFESSOR K.L. CHOPRA

Head
Thin Film Solid State Technology Cell
Department of Physics
Indian Institute of Technology, Delhi
New Delhi 110 016
INDIA

DR. L.K. MALHOTRA

Assistant Professor
Centre of Material Science and Technology
Department of Physics
Indian Institute of Technology, Delhi
New Delhi 110 016
INDIA

ACKNOWLEDGMENT

I am extremely grateful to Professor K.L. Chopra and Dr. L.K. Malhotra for their invaluable guidance, constant encouragement and objective criticism during all stages of this work.

It has been my privilege to be a member of the Thin Film Group. I have always enjoyed the cooperation of all my colleagues. I wish to thank Dr. V. Dutta and Dr. A.K. Mukherjee for their help in designing of instruments. I thank Dr. D.K. Pandya and Dr. P.K. Gogna for their useful discussions. I thank Dr. A. Banerjee, Dr.S.Rajagopalan and Dr. T.V. Rao for their help in XPS/AES studies. I would like to thank Mr. G.B. Reddy for his critical discussions and the help during this study. I thank Mr. S. Major and Mr. Bodhraj for the help in fabrication of spray system. I thank Ms Uma Rani and Mr. Bharat Bushan for their extensive help in the preparation of this thesis.

I thank my family members for their constant encouragement. I thank all my friends especially Mr. M. Ganapathy and Mr. S. Balasundaram for their willing help and who made my stay in IIT Campus a pleasant one.

The financial assistance rendered by IIT Delhi is gratefully acknowledged.

Finally, it is my pleasure to thank Mr. P.M. Padmanabhan Nambiar, who did the typing of this thesis.

K. CHIDAMBARAM

ABSTRACT

The work reported in this thesis has been directed towards developing spectrally selective surfaces for use in different temperature ranges, for photothermal conversion of solar energy. Coatings of cobalt oxide and a combination of cobalt oxide with iron oxide or cobalt sulphide have been investigated for use as high temperature selective surfaces. It has been shown that cobalt oxide and cobalt oxide containing iron oxide are good materials for high temperature applications. A simple spray pyrolysis process has been used to prepare these selective blacks. Detailed structural analysis has been carried out using Auger Electron Spectroscopy (AES), X-ray Photoelectron Spectroscopy (XPS), X-ray and electron diffraction techniques. The refractive index n and extinction coefficient k have been calculated from reflectance and transmittance data measured on coating deposited on glass substrate. The calculated reflectance values (using the above n and k) have been shown to be in close agreement with those obtained experimentally.

A systematic determination of the integrated solar absorptance (α) and hemispherical thermal emittance (ε) has been done by setting up different techniques (calorimetry, radiometry, heat balance and integrating sphere reflectometer) for their evaluation. The accuracy of each technique and its limitation in terms of surface roughness and spectral characteristics has been established.

Pure cobalt sulphide coatings have been investigated for medium temperature applications. Techniques of electroplating and electrochemical conversion have both been employed. Plating has been carried out both in aqueous and non-aqueous solutions. Various parameters involved in the two techniques like composition, concentration, temperature, current density, pH and time have been standardized.

An inexpensive withdrawal method has been used to obtain selectivity from commercial points for use in lower temperature ranges.

Accelerated humidity and thermal cycling test results are reported for each coating.

C O N T E N T S

			Page
		Acknowledgment	
		Abstract	
CHAPTER I		INTRODUCTION	1
	1.1	Absorptance and Emittance	4
	1.2	Gain of Selectivity	6
	1.3	Methods of Obtaining Selectivity	8
	1.4	The Present Work	25
CHAPTER II		EXPERIMENTAL TECHNIQUES	27
	2.1	Substrate Preparation	27
	2.2	Deposition Techniques	29
	2.3	Characterization of the Coatings	34
	2.4	Viscosity Measurement	37
	2.5	Stability Studies	37
CHAPTER III		EVALUATION OF SOLAR SELECTIVITY	39
	3.1	Integrating Sphere Reflectometer	39
	3.2	Radiometric Technique	46
	3.3	Heat Balance Technique	49
	3.4	Calorimetric Technique	51
	3.5	Comparison of Measurement Techniques	56
CHAPTER IV		SPRAY PYROLYSED BLACK COBALTS	60
	4.1	Introduction	60
	4.2	Cobalt Oxide	60
	4.3	Mixed Cobalt Oxide - Cobalt Sulphide/ Iron Oxide Films	73

CONTENTS (CONTD.)

		Page
CHAPTER V	COBALT SULPHIDE COATINGS BY CHEMICAL CONVERSION AND ELECTROPLATING	81
	5.1 Chemical Conversion	82
	5.2 Electroplated Cobalt Sulphide	88
CHAPTER VI	PARTIALLY SELECTIVE BLACK PAINT COATINGS	94
	6.1 Spray Coating	95
	6.2 Dip Coating	96
CHAPTER VII	CONCLUSIONS AND SCOPE FOR FURTHER WORK	102
	7.1 Conclusions	102
	7.2 Scope of Further Work	103
APPENDIX	CALCULATION OF OPTICAL CONSTANTS	105
	REFERENCES	108
	LIST OF PUBLICATIONS	117
	BIO DATA	118