THESIS FOR PH.D. IN PHYSICS

SUBMITTED BY

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Title of thesis

PREPARATION OF RARE EARTH DOPED LUMINESCENT DEVICES ON GLASS SUBSTRATES BY SPRAY PYROLYSIS TECHNIQUE

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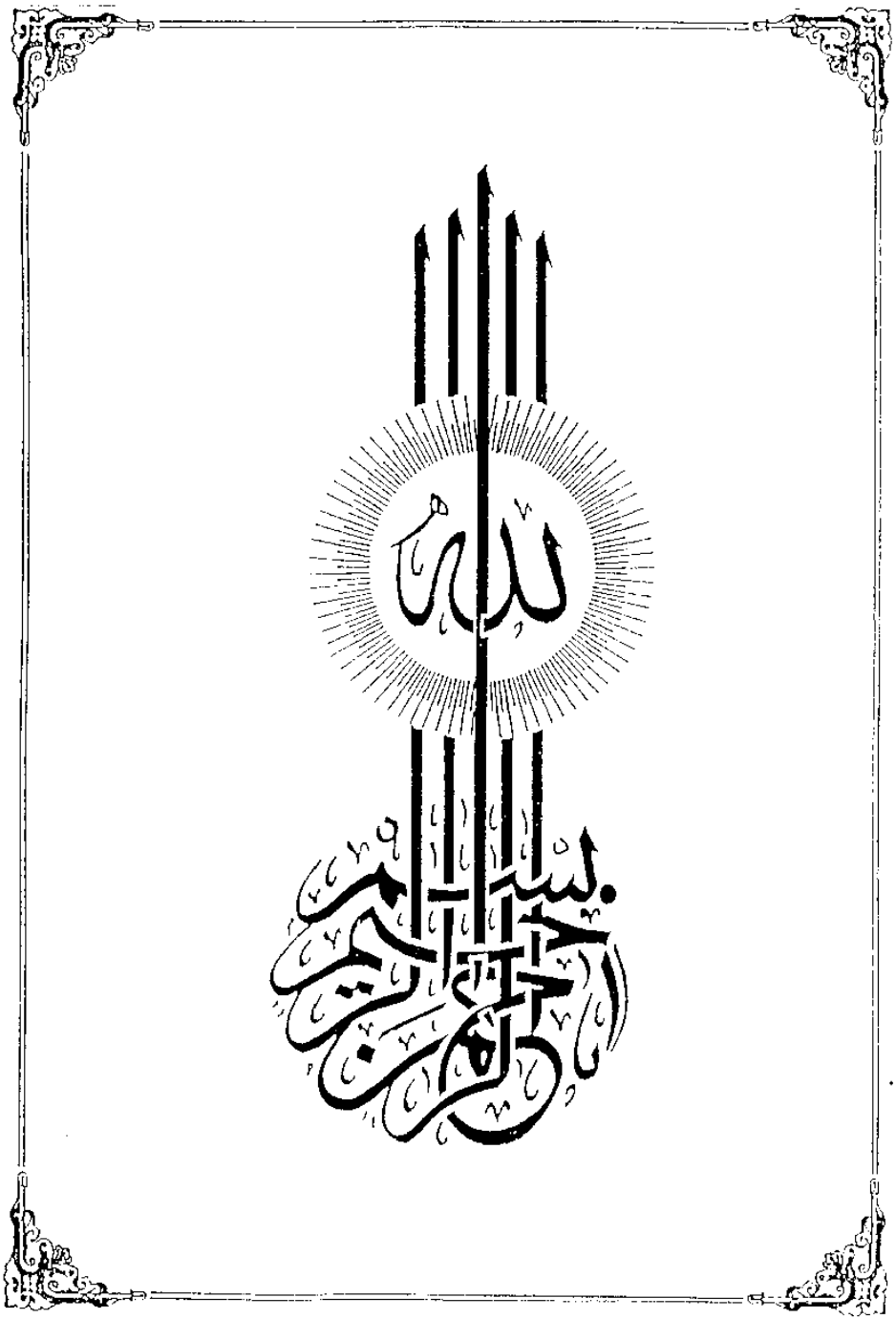

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ABBREVIATIONS

σ	Electrical Conductivity ($\Omega^{-1}.cm^{-1}$)
ρ	Resistivity (Ω.cm)
λ_g	Cut off Wavelength
A	Sample Area (cm^2)
CVD	Chemical Vapor Deposition
D	Crystallite Size
E_A	Activation Energy (eV)
ECD	Electro-Chemical Deposition
E_g	Absorption Energy (Band Gap)
EL	Electro-luminescence
I(hkl)	Measured Peak Intensity
I_0(hkl)	Intensity in The ASTM Data File
k	Boltzmann Constant (1.38062×10^{-23} J K^{-1})
L	Distance between Potential Electrode (cm)
MISIM	Metal/Insulator/Semiconductor/Insulator/Metal (EL Device)
N	Number of Reflections
N_A	Avogadro's Number (6.02217×10^{23} mol^{-1})
PVD	Physical Vapor Deposition
Ra	Surface Roughness (ISM)
RE	Rare Earth Elements
R_g	Gas Constant (8.315 $J.Mol^{-1}.K^{-1}$)
R_s	Sheet Resistance
Rz	Thickness (ISM)
SPT	Spray Pyrolysis Technique
T	Annealing Temperature
T(λ)	Transmittance (%)
TC(hkl)	Texture Coefficient
TG	Texture Goniometry
t_s	Spray Time
T_s	Substrate Temperature

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ABSTRACT

A simple spray pyrolysis technique has been employed with the aim of preparing a five-layer sandwich that may be used as an electroluminescence device (EL).

ZnO doped with Mn and rare earth elements (Pr, Ce, Nd, Er, Tb, and Sm) have been prepared to be used as an active layer. ZnO doped with Al, In, F and Cu, has been tested to be used as a conductive electrode layer (in case of Al, In and F) or as an insulator layer (in case of Cu). Also, Y_2O_3 is tested to be used as an insulator layer. SnO_2 doped with F has been prepared to be used as a conductive electrode.

The main parameters (substrate temperature, spray time and doping material type and its concentration) which affect the structural, optical and electrical properties of these films have been investigated. X-ray diffraction XRD, transmission electron microscopy TEM, texture goniometry (Pole figures) and phase microscopy were used to investigate the microstructure of the prepared layers, while the surface topography was elucidated by scanning electron microscopy SEM and atomic force microscopy AFM. The elemental analyses were made by EDX units attached to TEM and SEM. The optical

measurements were investigated by using UV/VIS-spectroscopy and interference shearing microscopy ISM.

ZnO and SnO_2 films consist of aligned crystals with nm dimensions. Films with optical transmission T > 85% and structural uniformity in terms of average roughness < 10 nm have been obtained. The first attempts to prepare a five-layer sandwich that can be used as EL device has been made.

SUMMARY

The spray pyrolysis technique SPT, was used to produce a five-layer sandwich that can be used in electroluminescence device EL. Many nozzle generations were made till we have an optimized one, which can be used, in laboratory scale and also with some modifications on a large scale (industry).

The different experimental parameters were tested till we had the best film homogeneity and quality (structural, optical and in some cases electrical). The distance between the nozzle and the oven, the gas flow rate (air) and the solution rate were fixed at the optimum values 15-20 cm, 1.1 bar and 0.3 ml/min respectively.

The efficient device has to be in sandwich shape with at least five layers MISIM (Metal / Insulator / Semiconductor doped with RE / Insulator / Metal). The structural, optical, and electrical properties were studied, for each of the layers, to choose the best material according to the layer function (MISIM) and to optimize it after that. Each of the layers has been prepared at different substrate temperatures T_s in the range from 673 K to 873 K, and different spray time t_s starting from 1 minute to 80 minutes, for each substrate temperature.