DOPED, ALLOYED AND PURE HYDROGENATED AMORPHOUS SILICON PREPARED BY REACTIVE ION BEAM SPUTTERING

By

JAGRITI SINGH

A thesis submitted to the
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for the award of the degree of
DOCTOR OF PHILOSOPHY

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DEDICATED

TO

MY PARENTS AND TEACHERS

CERTIFICATE

This is to certify that the thesis entitled "DOPED, ALLOYED AND PURE HYDROGENATED AMORPHOUS SILICON PREPARED BY REACTIVE ION BEAM SPUTTERING" submitted by Miss Jagriti Singh, to the Indian Institute of Technology, Delhi for the award of 'Doctor of Philosophy' is a record of bonafide research carried out by her. Miss Jagriti Singh has worked under my supervision for submission of this thesis, which to my knowledge has reached the required standard.

The Thesis, or any part, thereof, has not been submitted to any other University or Institute for the award of any degree or diploma.

(Prof. K.L. CHOPRA)
Physics Department
Indian Institute of Technology,
New Delhi-110016, India.

October, 1985

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Jagriti Singh

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(JAGRITI SINGH)

ABSTRACT

Reactive Ion Beam Sputtering Technique (RIBS) for depositing hydrogenated amorphous silicon (α-Si:H) has been set up in an ultra high vacuum system. Various deposition parameters have been optimized to get a device quality material.

To ellucidate the role of hydrogen in terms of its size and electronegativity effects in hydrogenated amorphous silicon and also in search of better quality material it has been alloyed with halogens such as chlorine and bromine and thus obtained material studied in detail for its structure and optoelectronic-properties.

Looking for dopants other than phosphine (or Phosphorous) and diborane (or Boron), the material (α-Si:H) has been successfully doped n-type with nitrogen. However when incorporated in higher concentration it is found to predominantly alloy with α-Si:H. The two, doping and alloying regimes, have been separated in terms of electrical and optical properties of the material as well as in terms of chemical bonding configuration of the impurity atom. For the first time using X-ray photoelectron spectroscopy (XPS) technique, upper solid solubility limit of an impurity atom in an amorphous material has been found.

All the prepared materials (viz. α-Si:H in its pure, doped and alloyed form and under various deposition conditions) have been characterized for their structure using transmission electron microscopy (TEM) and scanning electron microscopy (SEM),

for hydrogen concentration and its various bonding configuration, along with that of other elements present in the amorphous silicon as base material, using infrared (IR) spectroscopy, and for composition and purity using Auger electron spectroscopy (AES). XPS was also used in case of the nitrogenated material for structural analysis. Activated nuclear resonance reaction analyses was used to crosscheck the results from IR measurements for total H content. The optical constants, bandgap of the materials and spectral dependence of their respective absorption coefficients were calculated from the reflectance and transmission data. For the electrical and other optoelectronic properties and for information on density of states in the gap, measurements of temperature dependence of conductivity, photoconductivity spectral and field dependence of photoconductivity and space charge limited current were done. Various material properties have been correlated with each other and also with the various deposition parameters. An undestanding about the various characteristic parameters and about the tailorability of the material with specific properties within a certain limited range has also been developed.

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