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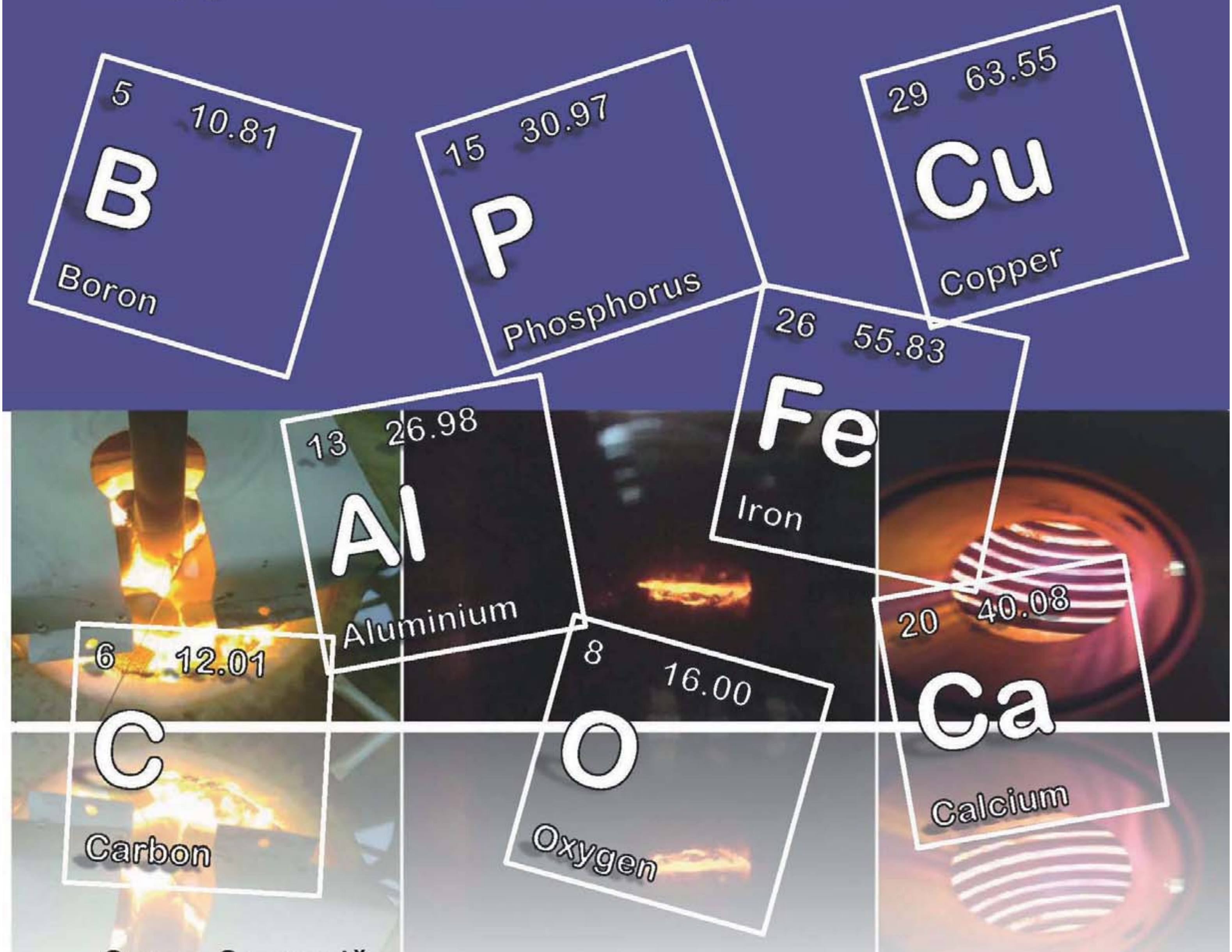

Samo Semenič

UPGRADED METALLURGICAL SILICON FOR APPLICATION IN THE PHOTOVOLTAIC INDUSTRY

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UPGRADED METALLURGICAL SILICON FOR APPLICATION IN THE PHOTOVOLTAIC INDUSTRY

von
Samo Semenič

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Verkehrs- und Maschinensysteme
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Preface

The present thesis reflects my work during the last four years at the Solarvalue AG in Berlin. During this time I was supported by many persons who inspired me in various discussions. Furthermore, they gave me their advice, and I always enjoyed the friendly atmosphere at the Solarvalue AG as well as the intensive scientific cooperation with the research group Von Ardenne GmbH in Dresden, Retech Systems LLC in Ukiah, California and to TU Berlin, Fakultät V – Verkehrs- und Maschinensysteme, Institut für Mechanik in Berlin.

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Berlin, 9. November 2011

Samo Semenič

Contents

List of Tables

List of Figures

List of Abbreviations

λ	Wavelength
E_λ	Photon energy
H	Planck's constant
c	Speed of light
E_G	Semiconductor band gap
τ_{Aug}	Auger-limit lifetime
C_{Aug}	Auger coefficient
τ_{SRH}	Shockley-Read Hall lifetime
τ_{Rad}	Radiative lifetime
N_{A}	Dopant concentration
X_{S}	Solid solubility of impurities
k_0	Segregation (distribution) coefficient
C_{S}	Solid solubility limit at the melting point
k	Boltzmann constant
L	Solubility
ΔS	Entropy change
ΔH	Enthalpy change
T	Temperature
J_n	Current density of electrons
q	Charge
u_n	Mobility
E	Electric field
k_{n}	Segregation coefficient of n-type impurities
k_{p}	Segregation coefficient of p-type impurities
n	Carrier concentration
p	Resistivity
N_{a}	Acceptors density
N_{d}	Donors density
L_{e}	Electron minority carrier diffusion length
u_{e}	Electron mobility
τ_{e}	Electron minority carrier lifetime
L_{h}	Hole diffusion length
u_{h}	Hole mobility
τ_{h}	Hole lifetime
N_{P}	Density of phosphorus
N_{B}	Density of boron
ρ_{Si}	Mass density of silicon
m_{P}	Mass of phosphorus atom
X_{P}	Phosphorus concentration in ppmw
X_{B}	Boron concentration in ppmw
ρ	Static resistivity
E	Magnitude of the electric field
J	Magnitude of the current density
R	Electrical resistance of the material
l	Length
A	Cross-section
σ	Conductivity

ΔG	Gibbs energy
k_0	Segregation coefficient
X_S	Concentration of impurities in the solid stage
X_L	Concentration of impurities in the liquid stage
T_L	Liquidus temperature
T_S	Solidus temperature
X_0	Initial concentration of the impurity
f_S	Volume fraction of solid phase
f_B	Coefficient of activity
p	Partial pressures
p^*	Vapor pressure
a	Activity
N	Molar concentration
p_A	Actual vapor pressure of component A
p_B	Actual vapor pressure of component B
a_A	Activity of component A
a_B	Activity of component B
p_A^*	Saturation vapor pressure of component A
p_B^*	Saturation vapor pressure of component B
N_A	Concentration of component A
N_B	Concentration of component B
γ_A	Activity coefficients of component A
γ_B	Activity coefficients of component B
β_A	Ratio of the concentrations of components in the two phases