

Preface

Solar photovoltaic technologies have been growing with over 35% CAGR annually, with annual production now crossing 77,000 MW. This is extremely impressive high production volume by any measure. About 90% of this production is done using crystalline Si wafers. Despite the competition from the other materials and technologies, strong growth in the crystalline Si cell technology and improvement in efficiency has led to strong position of this technology in current market.

There is further scope for improvement in technology which will lead to cost reduction. International technology roadmap on crystalline Si cell technology has identified several areas of improvements in crystalline Si cell like front metal contact, front and back surface passivation, bulk material, reduction in wafer thickness, and alternative anti-reflection techniques. It is anticipated that the future crystalline Si solar cells will be much thinner than the current standard of 180 microns. In this scenario efficient light harvesting becomes key to growth of the technology and cost reduction. Anti-reflection and light trapping techniques will play a key role in efficient light trapping by future solar cells. In this context, this book brings an insight into various aspects related to reflection, refraction, and light trappings in c-Si cell technologies. Basic physics and technology for light trapping in c-Si-based solar cell has been covered starting from traditional light trapping structure to advanced light trapping structures based on nanostructures.

Chapter 1 gives an overview of solar cell technology. In this chapter, different types of solar cell technologies have been discussed in brief and the importance of c-Si-based solar cell technology has been described along with the importance of light trapping technology.

Chapter 2 covers the main stream technology of c-Si solar cells. It explores development in design and technology of the c-Si solar cells from traditional to advanced device architecture. It highlights the historical development in cell design and technology along with the technological approach, which is being researched for next-generation c-Si solar cells. Some basics on solar cell performance and corresponding cell performance tracking parameters like open circuit voltage, short circuit current, maximum power point, FF, Efficiency, EQE and IQE, and their

interdependence has also been discussed. Toward the end of the chapter, International Technology Roadmap for Photovoltaic (ITRPV) has been introduced.

Chapter 3 focuses on the interference based anti-reflection and light trapping methodologies for solar cell applications. Detailed analysis of interference based anti-reflection and principle behind the observed phenomenon has been covered. Correlation with reflectance minima with wavelength and dielectric layer parameters has been presented. Experimental measurements of reflectance for various suitable anti-reflection coatings has also been presented and compared with the theoretical results. At the end, benefits and limitations of dielectric based reflectance have been discussed in the context of c-Si solar cells.

Chapter 4 presents an exploration on methodologies of texturization for light trapping. Starting from impact of surface morphology on light trapping, detailed analysis, and principle behind the observed phenomenon from textured surfaces has been discussed. Analytical analysis on current generation potential based on optical path length enhancement capability for different light trapping structures appropriate for c-Si solar cells has been covered.

Chapter 5 covers process technology for making textured surfaces in c-Si solar cells. Starting with c-Si crystal structure and role of crystal planes, wafer type and orientation in deciding the chemical process chemistry for texturing have been covered. Also, chemical processes used for achieving different shape of textures on surface in mono as well as multi c-Si wafers have been discussed along with the principle behind the process, which makes texturization possible. Toward end, practical implications involved in chemical texturing based technology has been discussed in the context of manufacturing of the c-Si solar cells.

Chapter 6 presents a comparative study on dielectric layer based light trapping, texture-based light trapping, and combination of the both light trapping structures on the solar cell performances. Also, implications and solutions have been discussed in context of next-generation c-Si solar cells.

Chapter 7 gives latest developments in traditional light trapping structures. In this chapter, discussion is made mainly on the advancement in traditional light trapping, e.g., development and techniques for nano-sized textures, back reflectors together with the cell designs incorporating the latest developments.

Chapter 8 introduces principles and technologies of plasmonics for an alternate light trapping method. Historical developments in the area of plasmonics and the review on applicability of plasmonics based light trapping technology in solar cells have been discussed. Relevant light trapping techniques such as scattering, local field enhancement, and surface plasmon polariton (SPP) has been discussed along with the associated mechanism involved for efficient light trapping. Mie scattering theory and the mathematical solutions to calculate Mie efficiencies for different size, shape, dielectric medium based nanostructures have also been covered.

Chapter 9 focuses on exploration of plasmonic-based technology for light trapping applications in c-Si solar cells. It presents updates on plasmonic-based light trapping structure research and developments for c-Si solar cells. Need and applicability of such emerging plasmonic-based light trapping structures in the

context of c-Si solar cells has been discussed. Also, a broad overview of limitations of plasmonic-based techniques and their probable solutions have been presented.

Chapter 10 discusses the future scope and requirements of research for different light trapping technologies in context of future development of c-Si solar cells. Discussion made in this chapter is focused mainly on the future advancement needed in light trapping structure development and a brief projection for certain areas which can be of immediate interest to research community.

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