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SENTECH Erfolg durch Leistung

Spectroscopic Ellipsometry of Layer Stacks for Antireflective and Passivating Coatings on Textured Silicon Solar Cells

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• Introduction

PECVD grown SiN_x films are state of the art anti-reflective coatings for Si wafer based solar cells. For further improvement of cell efficiency, double layer stacks are applied recently. Thin SiO_2 layers are used for improved electrical passivation of the Si substrate.

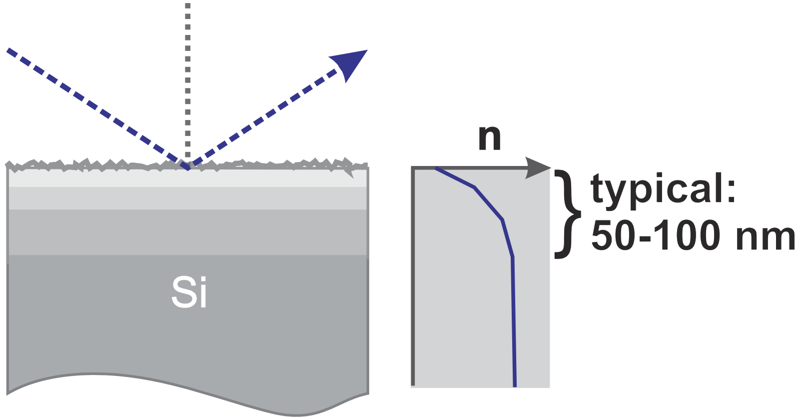
Film thickness, optical constants of these films as well as influences of the texture and diffusion are measured by spectroscopic ellipsometry using the **SE 800 PV** ellipsometer.

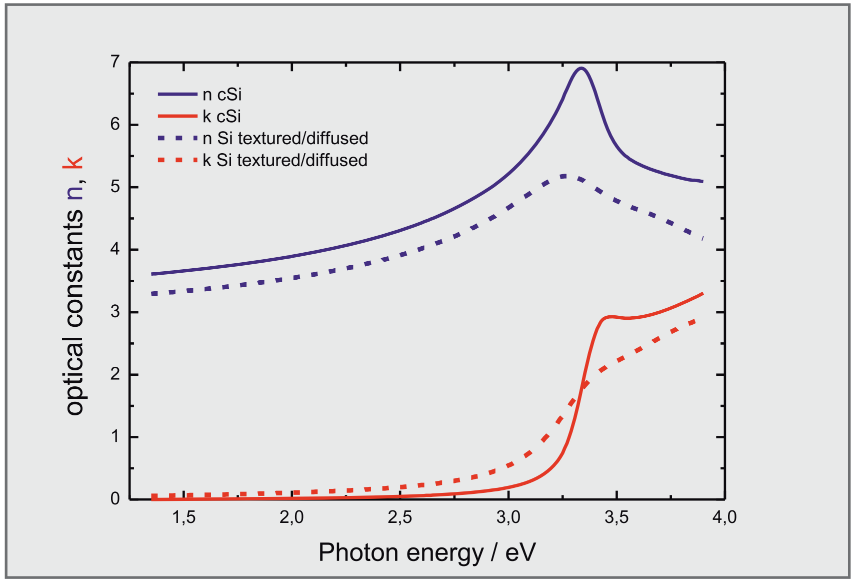
This spectroscopic ellipsometer is designed for PV applications to handle weak measurement intensities and to compensate depolarization effects induced by the texture.

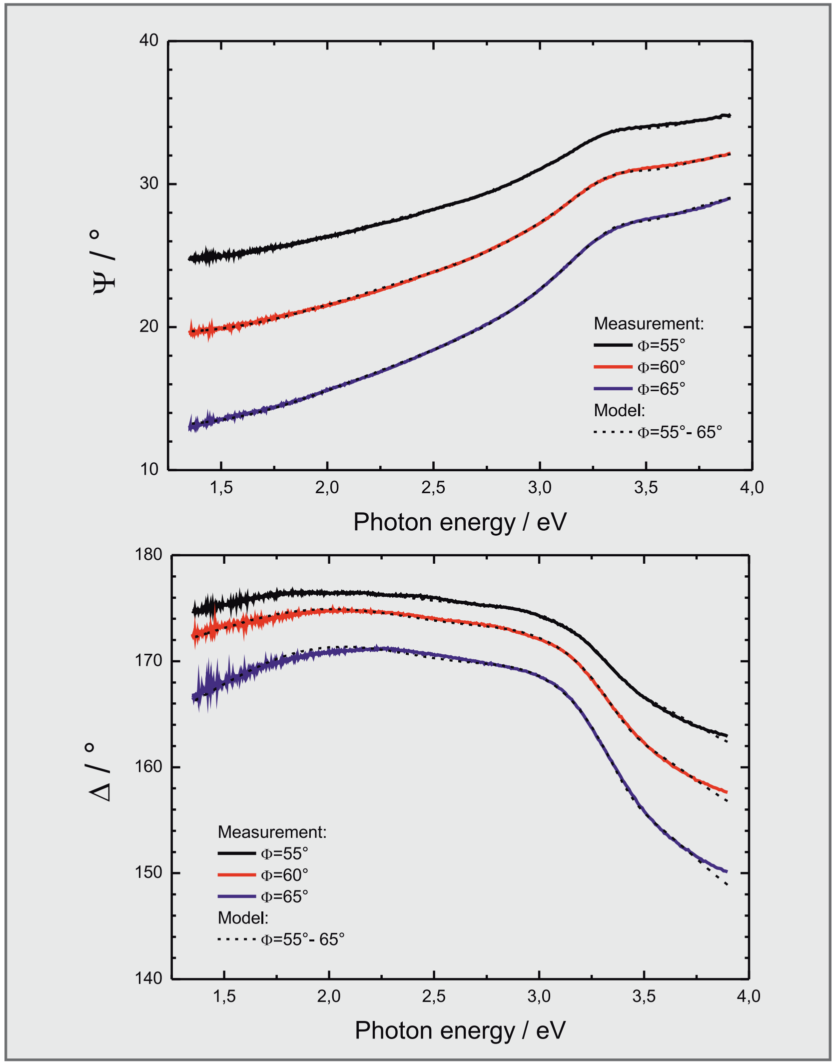
SE 800 PV

• Textured and diffused mc-Si substrate

The texturing and diffusion of the mc-Si substrate result in modified optical constants n, k of Si and a surface gradient.



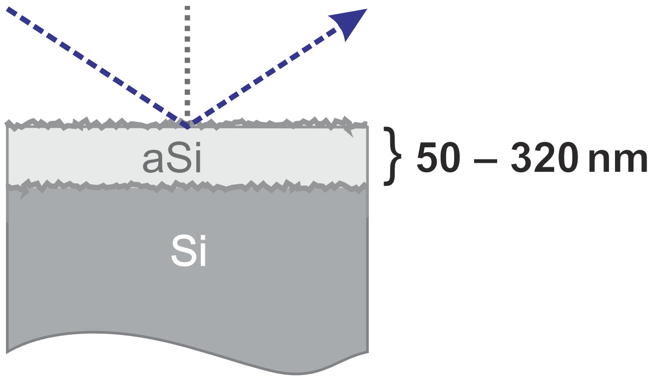


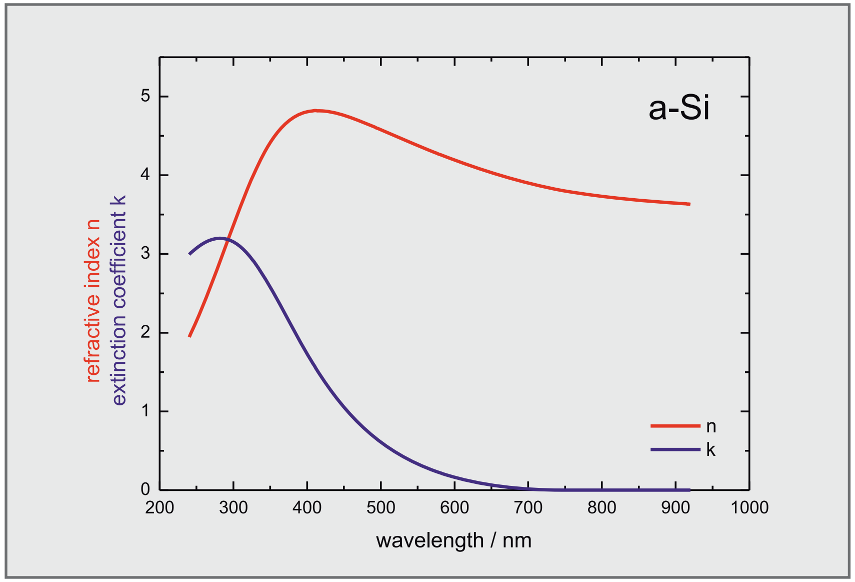


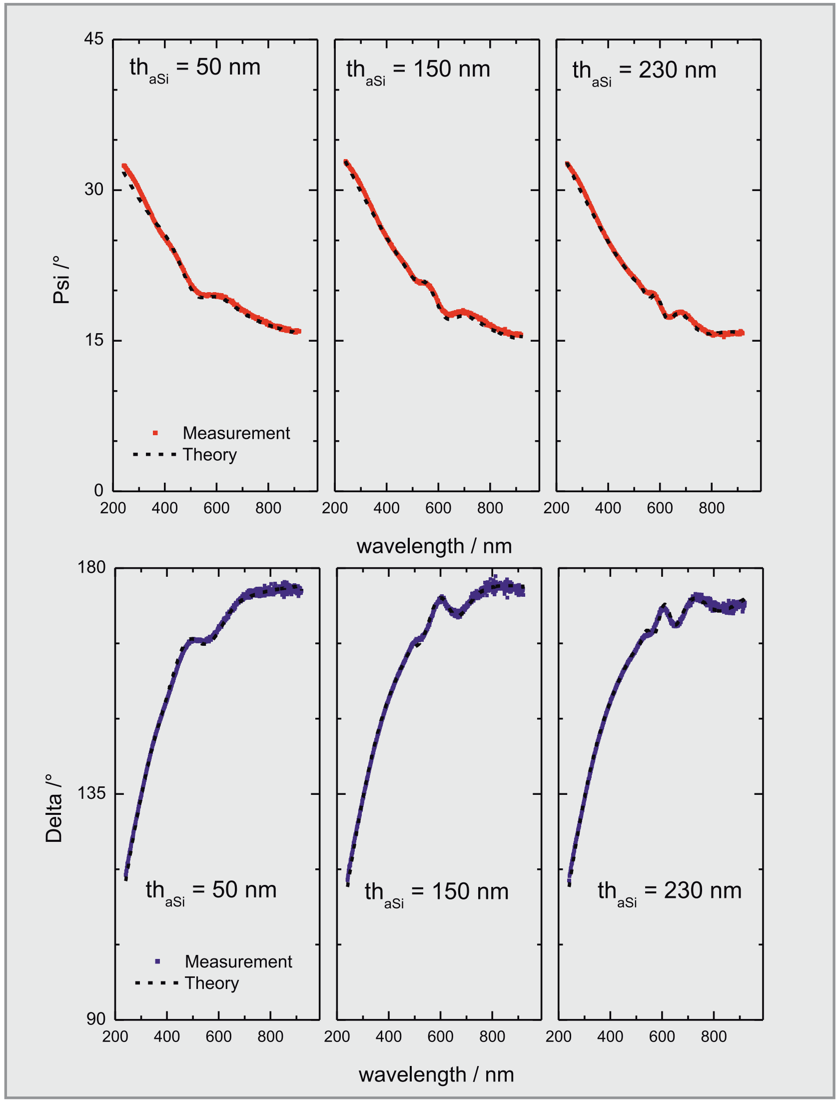
• a-Si / mc-Si (textured)

aSi layer of different film thickness from 50 nm to 320 nm

a-Si / mc-Si (textured)

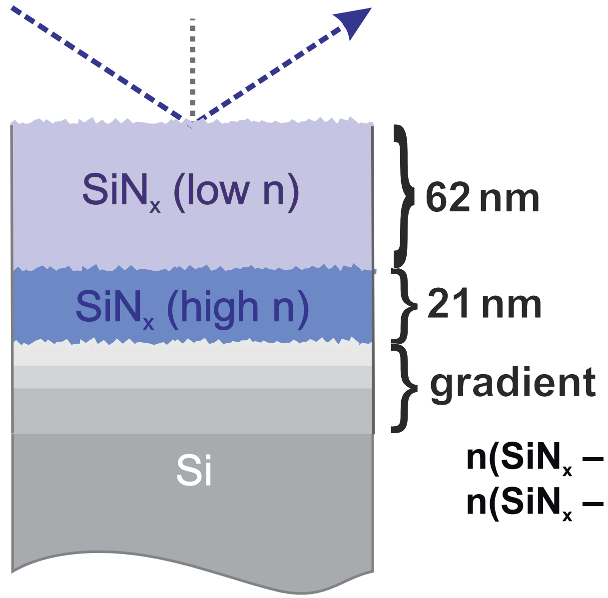






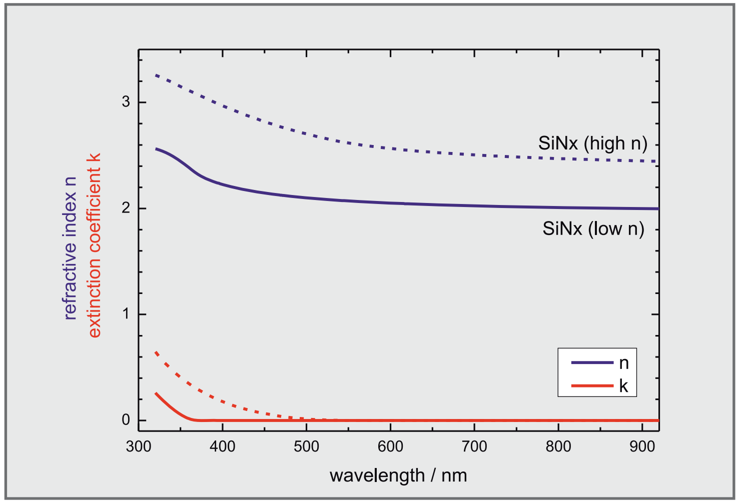
• SiN_x (low n) / SiN_x (high n) / mc-Si

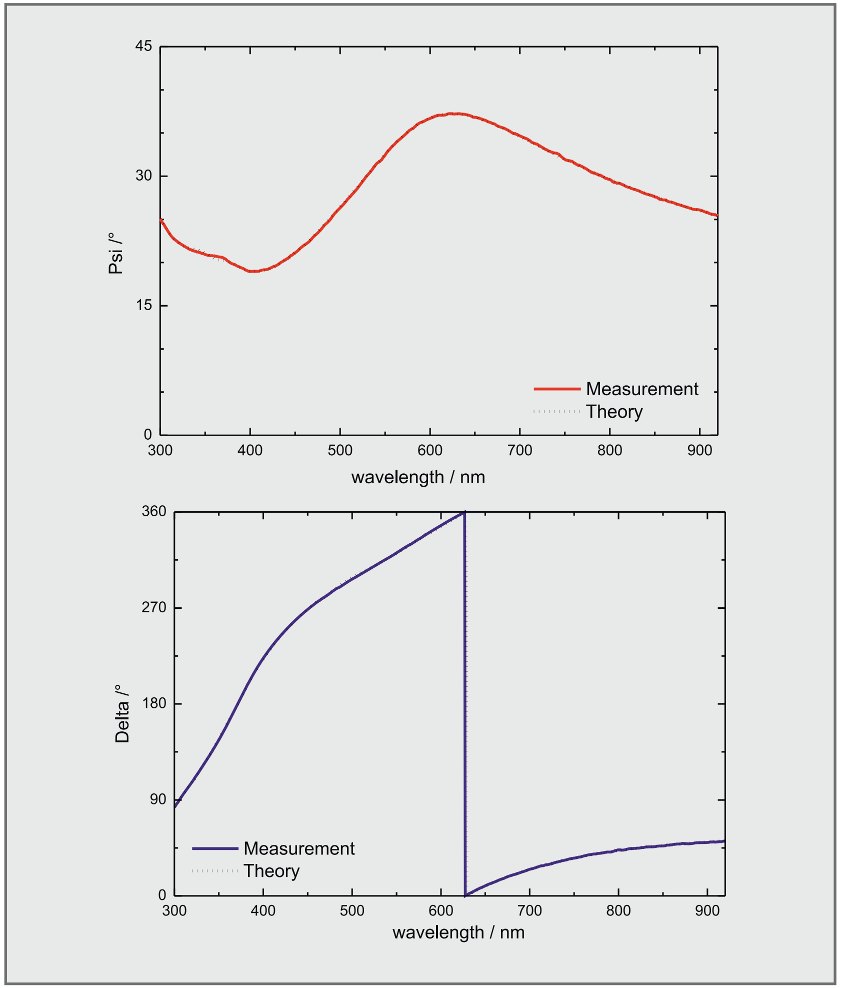
SiN_x (low n) / SiN_x (high n) / mc-Si (textured)



A thin SiN_x layer with high n is combined with a standard low n SiN_x layer for better electrical passivation while retaining antireflective properties

n(SiN_x – low n) = 2.04 (632.8 nm)
n(SiN_x – high n) = 2.53 (632.8 nm)

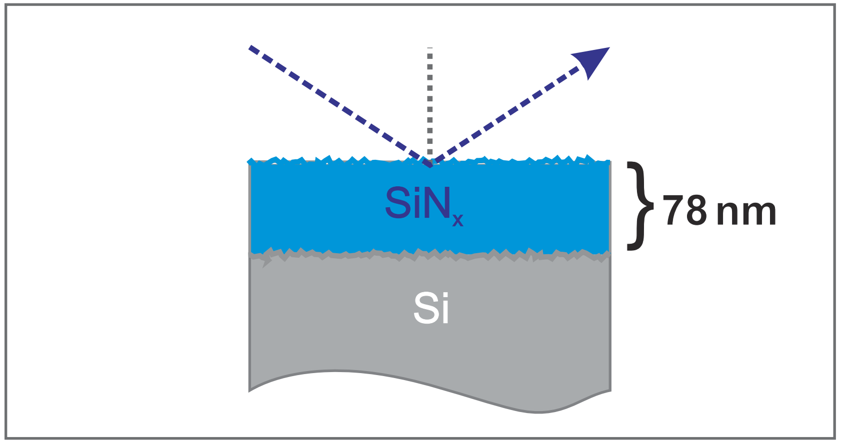


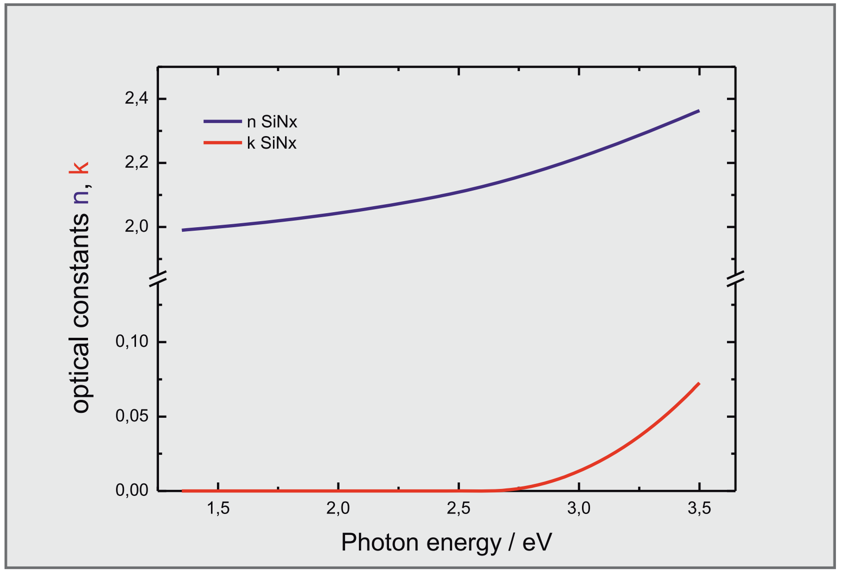


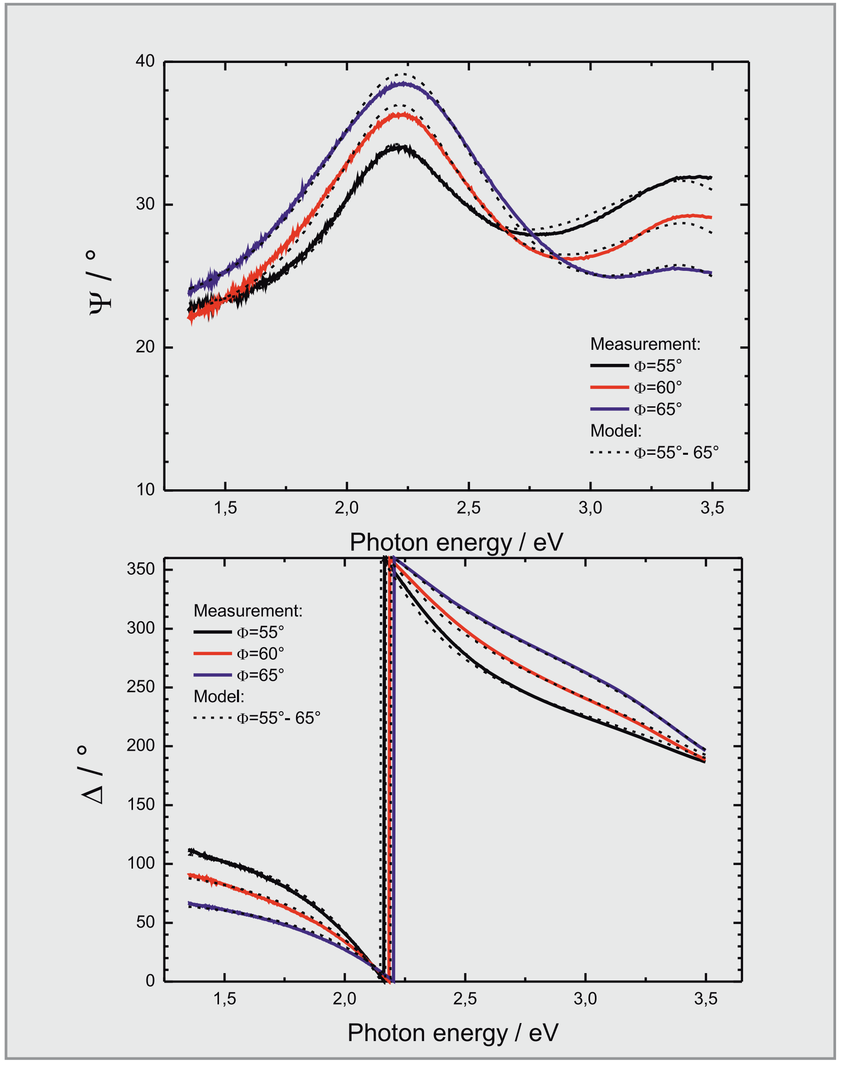
• SiN_x / mc-Si (textured)

State of the art SiN_x/ mc-Si single film example:

SiN_x / mc-Si (textured)



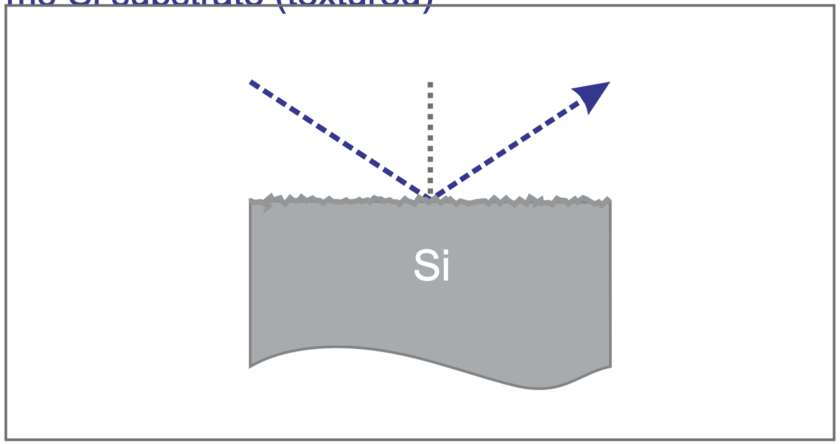




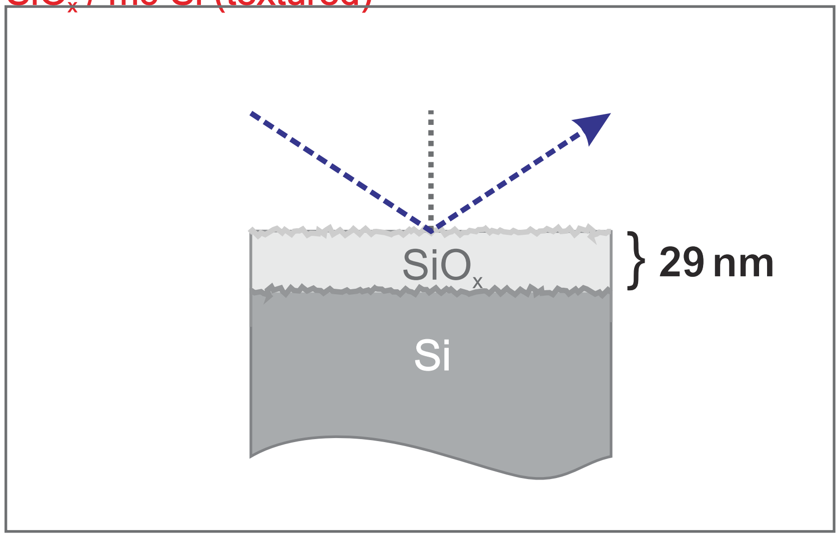
• Thin SiO_x / mc-Si (textured)

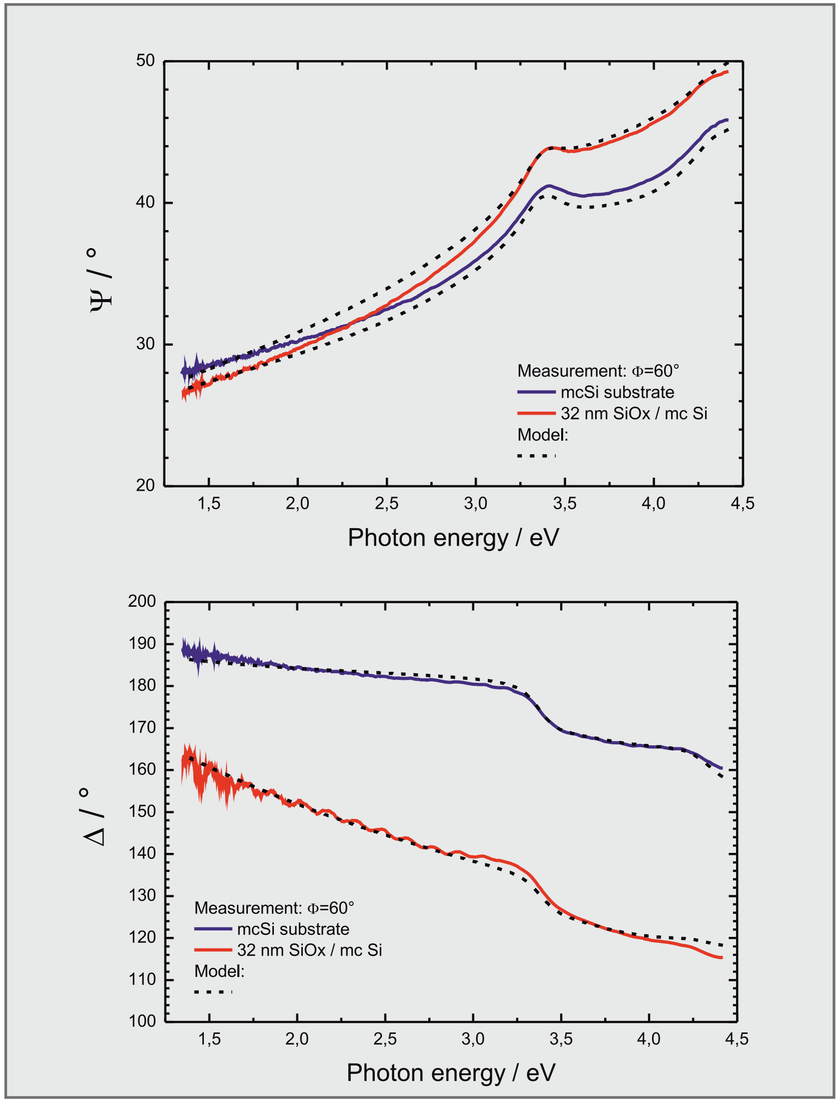
Comparison between mc-Si substrate and thin SiO_x sample

mc-Si substrate (textured)



SiO_x / mc-Si (textured)



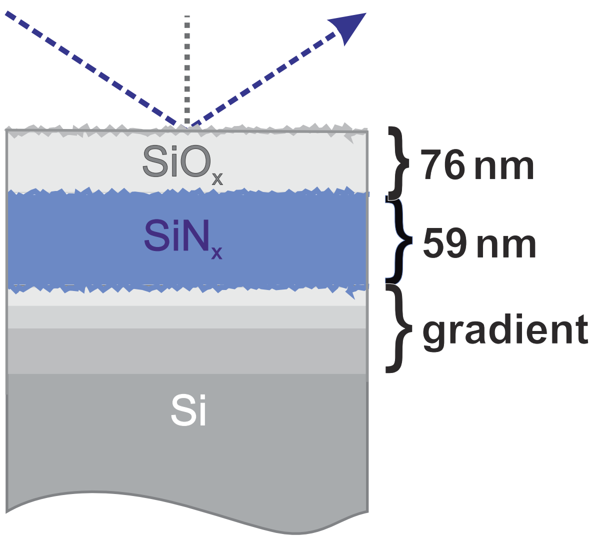


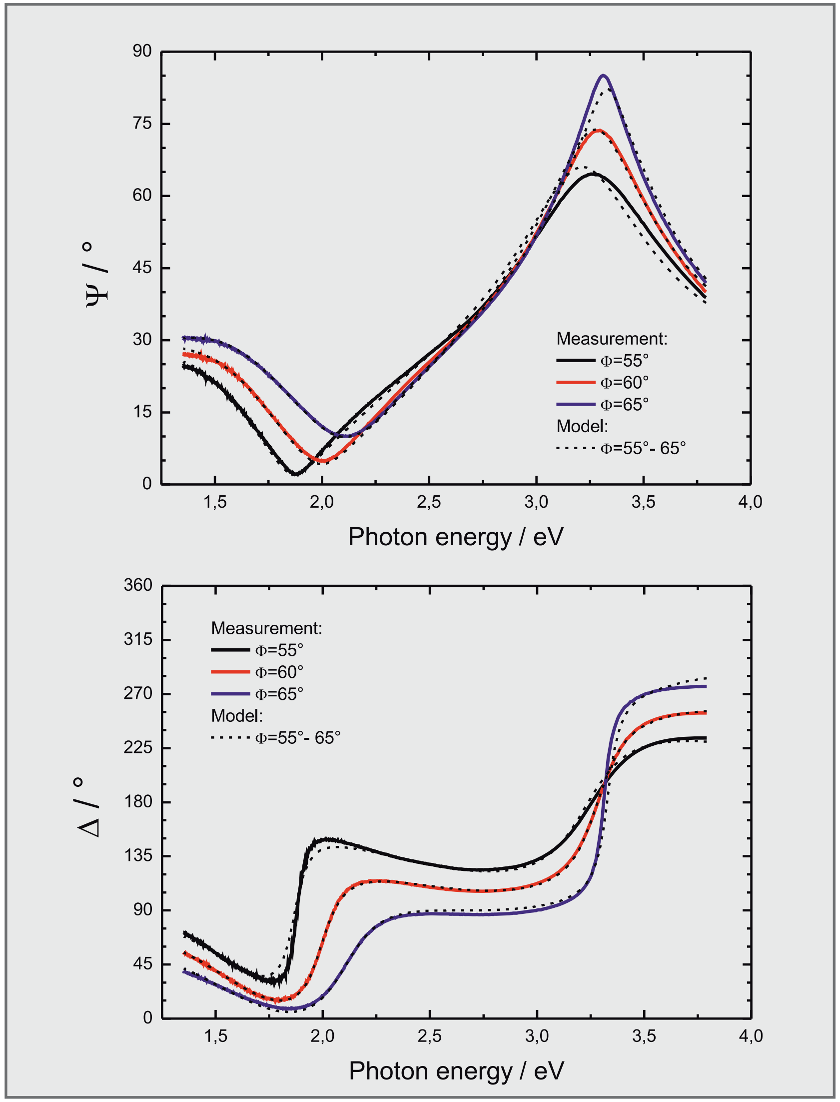
• SiO_x / SiN_x / mc-Si (textured)

Double layer stack of SiO_x and SiN_x film

SiO_x / SiN_x / mc-Si (textured)

n(SiO_x) = 1.45 (632.8 nm)
n(SiN_x) = 2.23 (632.8 nm)





• Conclusion

Spectroscopic ellipsometry (SE) is able to analyze typical stacks on Si-wafer based solar cells.

The effects of P-diffusion, single films of a-Si, SiO_x, and SiN_x can be measured and analyzed concerning thickness and optical constants n, k. SE is also able to measure multiple layer stacks like SiO_2 / SiN_x or SiN_x double films with low and high refractive index, respectively.

The ellipsometer must be capable of handling extremely weak measurement intensities like SENTECH **SE 800 PV**.

The mathematical techniques to compensate depolarization effects and to describe the influence of the texture allow proper modeling of the diffused substrate and the anti-reflective films concerning optical constants and film thickness.