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Development and optimization of the anti-reflective layer for SWIR devices

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Abstract

The short-wave infrared (SWIR) is a range of the electromagnetic spectrum which has been extensively explored for optoelectronic devices such as photodetectors. These photodetectors in the SWIR can be used for a wide range of applications, such as civilian use in authenticating works of art to strategic military use or scientific use in space monitoring. The active absorption layers for these devices are usually III-V semiconductors (e.g., InGaAs or InP). Besides the active layers, one of the most important layers of the device is the anti-reflective layer. The importance of optimizing this layer was made evident with the current solar cell world record [1]. This layer aims at improving the efficiency of the device by reducing the loss due to reflection at the surface [2]. It also improves the image contrast by reducing the transmission of stray light. Several materials can be used to form the anti-reflective layers, such as Al_2O_3, TiO_2, and other dielectrics, depending on the application and device. In this study, we sought to develop and optimize this layer for the 1.3 μm wavelength. Simulations were performed in order to obtain a structure that presented the lowest possible reflectance at this wavelength, as shown in Fig. 1. The optimized structure found is a sequence of four thin films alternating between TiO_2 and SiO_2 (64,88 nm; 25,24 nm; 39,53 nm; 196,86 nm), which resulted in a theoretical reflectance below 2%. Based on this simulation each of the thin film's deposition was calibrated and the anti-reflective layer was deposited on top of InP substrates using the sputtering technique. The reflectance of this anti-reflective layer was measured by spectrophotometry and can be seen in Fig. 2. The experimental curve has a small difference to the simulated curve, however, in the comparison between InP with and without the anti-reflective layer, a reduction of more than 25% in reflectance was obtained. Some parameters can still be refined to achieve lower reflectance, but as for now the proposed layer presents promising results.

References

[1] Fraunhofer ISE Develops the World's Most Efficient Solar Cell with 47.6 Percent Efficiency, Press Release (13), (2022)

[2] Giordano B. C. DeSimone and Gustavo S. Vieira, RBFTA 6(2), 20-43 (2019)

Figures

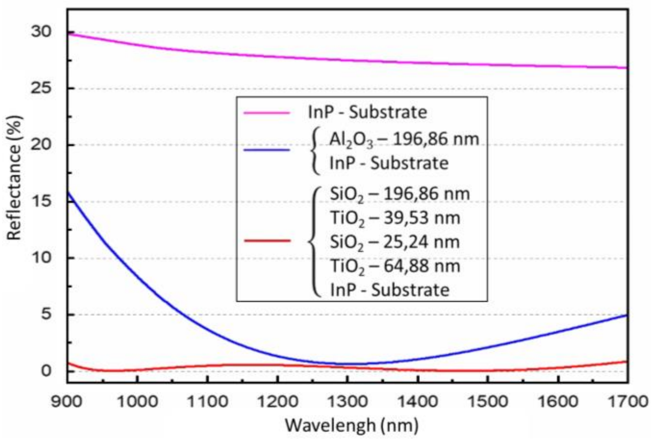

Figure 1: Optimization results for 1.3 nm of the simulated layers.

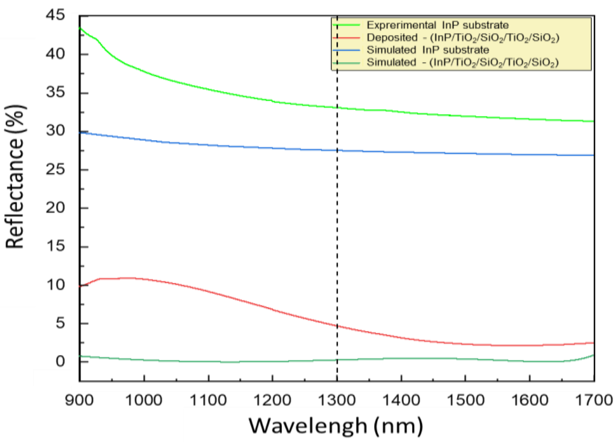

Figure 2: Comparative between the experimental result and the simulated one.