Passivation Optimization of Boron-Doped Polycrystalline Silicon Contacts on Textured Silicon for Photovoltaic Applications

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Abstract

Polycrystalline silicon (poly-Si) passivating contacts are a key technology for the new generation of high-efficiency silicon solar cells, such as tunnel oxide passivated contact (TOPCon) and interdigitated back-contact (IBC) architectures. These contacts combine low surface recombination with high carrier selectivity. While phosphorus-doped (n^+) poly-Si has shown excellent passivation properties, achieving similarly high-quality passivation with boron-doped (p^+) poly-Si remains challenging. One major limiting factor is boron segregation into the underlying interfacial silicon oxide (SiO_x), which degrades its integrity and reduces chemical passivation effectiveness [1].

In this study, we investigated (p^+) poly-Si contacts formed on textured silicon surfaces using a low-pressure chemical vapor deposition (LPCVD) process, followed by ex-situ boron diffusion using BCl_3. After hydrogenation, photoluminescence (PL) imaging revealed a central degradation pattern, while photoconductance decay measurements showed low carrier lifetimes. Our investigations attributed this pattern to a coupled effect between the LPCVD and boron diffusion processes, leading to thermally induced degradation confined to the poly-Si layer. The instability of the interfacial SiO_x under high-temperature conditions may be a critical factor affecting the final passivation quality.

To address this, we focused on engineering more thermally robust oxide layers and controlling the impact of boron doping on the oxide integrity. According to the literature, plasma-assisted nitrous oxides exhibit superior thermal stability under high-temperature processing conditions, making them promising candidates for stable passivating contacts [2]. We evaluated several oxide types, including thermal, chemically grown, and plasma-assisted nitrous oxides.

References

1. Basnet, R.; Yan, D.; Kang, D.; Shehata, M.M.; Phang, P.; Truong, T.; Bullock, J.; Shen, H.; Macdonald, D. Current Status and Challenges for Hole-Selective Poly-Silicon Based Passivating Contacts. *Applied Physics Reviews* **2024**, *11*, 011311, doi:10.1063/5.0185379.
2. Libraro, S.; Bannenberg, L.J.; Famprikis, T.; Reyes, D.; Hurni, J.; Genc, E.; Ballif, C.; Hessler-Wyser, A.; Haug, F.-J.; Morisset, A. Development and Characterization of N_2 O-Plasma Oxide Layers for High-Temperature p-Type Passivating Contacts in Silicon Solar Cells. *ACS Appl. Mater. Interfaces* **2024**, *16*, 47931–47943, doi:10.1021/acsami.4c10612.