CZシリコン結晶の原料融解過程における炭素輸送・制御の数値解析

Numerical analyses on carbon transport and control during the melting process of Czochralski silicon crystal growth

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Czochralski silicon (CZ-Si) crystal growth is invariably accompanied by the transport of impurities, such as carbon (C), oxygen (O), and related products, from chemical reactions in the high-temperature range. Reduction of C contamination in the grown crystal is required for the production of Si wafer with long carrier lifetimes. Contamination of C in Si crystal mainly originates from carbon monoxide (CO) generation on the graphite components, which is triggered from the preheating stage and reaches the maximum during the melting stage. To reduce the C contamination effectively, it is essential to control the C transport from its generation, incorporation and accumulation in the growth.

On the basis of the validated chemical models and transient global simulation, the effect of the gas-guide coating on C reduction was elucidated by taking the reaction between the silicon carbide (SiC) coating and gaseous Si monoxide (SiO) into account. Three cases, including no coating, SiC coating and no reaction, were compared for CO concentrations above the melt surface, as shown in Fig. 1. Gas flow control on the back diffusion of the generated CO was examined by the parametric study of argon gas flow rate, as shown in Fig. 2. According to the elucidated mechanisms of C accumulation, the final C content depends on the growth duration and contamination flux at the gas/melt interface.

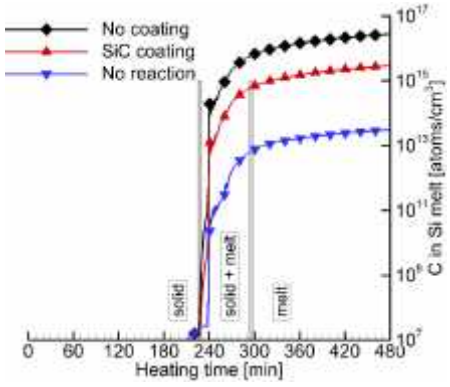

Fig. 1 Effect of SiC coating on C contamination

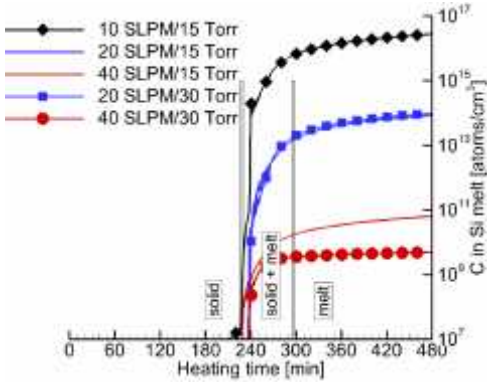

Fig. 2 Effect of Ar flow rate on C contamination

Acknowledgements

This work was partly supported by the New Energy and Industrial Technology Development Organization under the Ministry of Economy, Trade and Industry (METI).