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Effect of the total content of impurities on the effective distribution coefficient (K) during horizontal zone melting of metallurgical grade silicon

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One route to produce the Upgraded Metallurgical Grade Silicon (UMG-Si) is applying controlled solidification process. These processes use the solubility variation of an impurity in solid and liquid silicon know as effective distribution coefficient (K). So, to study the solidification processes it is necessary to determine K for silicon impurities, what was the objective of this study. It was used 2 samples of Metallurgical Grade Silicon (MG-Si) with different amount of impurities. Sample 01 presented 1,454 ppm of impurities and Sample 02 presented 254 ppm of impurities. Both were processed by 1 pass of zone melting at 1 mm/minute using an electron beam furnace with water cooled copper crucible. For sample 01 the effective distribution coefficient (K) for impurities with Ko ≤ 10^{-1} was found to follow the relation $K= 0.03\ Ko^{-0.063}$, where Ko is the "equilibrium distribution coefficient" obtained from the binary equilibrium diagram. In this sample impurities with Ko between 10^{-3} e 10^{-8} presented near the same effective distribution coefficient (K = 0.07 ± 0.02), which means that the effective distribution coefficient of a specific impurity depends on the total amount of impurities. For sample 02 that presented 5 times less total amount of impurities compared to sample 01 the K was 10 to 100 times lower than the K found in sample 01for the same impurity, except for manganese, due to the high evaporation of this element. Increasing the total amount of impurities in silicon also increases the concentration of impurities in the liquid in front of the solid / liquid interface, lowering the efficiency of the melting zone process. So, for UMG-Si production, the control of impurities presented in the MG-Si used is highly recommended.

Keywords: Silicon Purification, Zone Melting, Zone Refining, Solar Cells, Electron Beam Melting, Metallurgical Grade Silicon.

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