Technical Report

ISO/TR 23247-100

First edition
2025-05

Automation systems and integration — Digital twin framework for manufacturing —

Part 100: Use case on management of semiconductor ingot growth process

Systèmes d'automatisation industrielle et intégration — Cadre technique de jumeau numérique dans un contexte de fabrication —

Partie 100: Cas d'utilisation de la gestion du procédé de croissance des lingots de semiconducteurs

Reference number
ISO/TR 23247-100:2025(en)

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This document was prepared by Technical Committee ISO/TC 184, *Automation systems and integration*, Subcommittee SC 4, *Industrial data*.

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The semiconductor ingot growing process is an important step in the production of semiconductor wafers, which are used to manufacture electronic components such as integrated circuits and solar cells.

Despite advancements in automated ingot growth equipment, the conventional ingot growth process continues to face challenges due to the degree of human intervention required, it often relies on operators' experience and know-how. This dependence can lead to issues such as inaccurate quality, inconsistent machine setup, unstable temperature maintenance, and inconsistent melting.

A digital twin for the ingot growth process can effectively address these issues by simulating and optimizing the entire process in a virtual environment and reducing reliance on manual intervention.

Using a digital twin for monitoring and controlling the ingot growth process offers several advantages as follows:

— Real-time monitoring: a digital twin allows continuous and real-time monitoring of the ingot growth process. It provides detailed insights into key parameters such as temperature, growth rate, crystal quality, and dopant concentration. This enables operators to detect deviations or anomalies early on and take necessary corrective actions promptly.

— Process optimization: by analysing the data collected for the digital twin, it becomes possible to optimize the ingot growth process. Patterns and trends can be identified, allowing for adjustments in various parameters to improve yield, reduce defects and enhance the overall quality of the ingots and resulting wafers.

— Predictive maintenance: a digital twin can help predict maintenance requirements for the equipment used in the ingot growth process. By monitoring equipment performance and analysing historical data, the digital twin can help identify potential issues or deterioration in advance, enabling proactive maintenance and minimizing unplanned downtime.

— Training and simulation: a digital twin can be used for training operators and engineers. It provides a virtual environment where individuals can practice and simulate different scenarios without the need for actual physical equipment. This helps in enhancing operational skills, testing new strategies, and improving decision-making capabilities.

By leveraging the advantages of a digital twin, semiconductor manufacturers can gain deeper insights into the ingot growth process, optimize production parameters, enhance quality control, and improve overall productivity and efficiency.