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BSI Standards Publication

Automation systems and integration — Digital twin framework for manufacturing

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

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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

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

A list of all parts in the ISO 23247 series can be found on the ISO website.

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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.

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Automation systems and integration — Digital twin framework for manufacturing —

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

1 Scope

This document describes a digital twin for monitoring and controlling the semiconductor ingot growth process. The use case is analysed and designed using the ISO 23247 series. The result is a systematic view of the use case implementation and a high-level design of the digital twins, which can be directly implemented using the readily available tools and languages, including those supported by the relevant standards.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 23247-1, *Automation systems and integration — Digital twin framework for manufacturing — Part 1: Overview and general principles*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 23247-1 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
ingot
large, single crystal of semiconductor material, typically silicon, that serves as the starting material for the production of semiconductor wafers

Note 1 to entry: The ingot is grown through a process called ingot growth, where high-purity silicon is melted and then slowly solidified to form a large cylindrical crystal. This crystal is typically several inches in diameter and can be several feet long, depending on the intended use and requirements.

Note 2 to entry: The ingot is the primary raw material from which individual semiconductor wafers are cut. These wafers undergo further processing steps to fabricate electronic components such as integrated circuits (ICs) or solar cells. The quality and characteristics of the ingot, including its crystalline structure and impurity levels, play a crucial role in determining the performance and reliability of the resulting semiconductor devices.

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