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Knowledge-based Management Model of Semi-Finished Product Flows in the Multicluster Tools (MCT) in Semiconductor Production

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Abstract

To ensure the flexibility of the mechanisms of dynamic behavior and autonomy in Multicluster Tools (MCT), as well as to adjust the individual components of the model for conducting a simulation, it would be most expedient to apply the method of their functioning on the basis of knowledge-based model. It is based on an ontological approach, in which one can work out modalities for the flow management of semi-finished products at a simulation modeling of the MCT, as well as to simulate control actions. The authors investigated the ontological approach at a simulation flow modeling of the semi-finished products in the MCT and suggested the method of using regulations in the logical inference process, as one of the types of processing of knowledge choice procedure. The urgency of the current research is caused by the necessity to increase the productivity of multicluster technological complex.

Keywords: Knowledge-based Management Model, Multicluster Tools, Semiconductor Manufacturing

1. Introduction

In the electronic devices production process in semiconductor manufacturing, cluster installations and Multicluster Tools (MCT) with a single vacuum cycle began to be produced for the ordering, transportation, control and other manipulations (e.g. multi-level technological treatments or heating) with semi-finished products (plates) that were caused by the tightening of requirements for their production quality. At that, simulation methods of such systems are becoming increasingly popular.

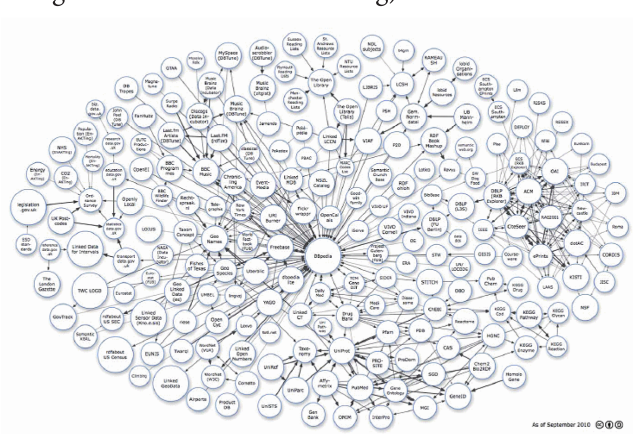

Figure 1. The example of ontology.

2. Materials and Methods

The choice of research methods is based on the logic and sequence of actions of a systemic nature, focused on analysis of current trends related to the development of the semiconductor manufacturing technologies[1–8].

3. Results and Discussion

The notion of ontology includes a description of the subject area, peculiarities and decision-making principles, which aim is to simplify the process of programming the behavior of all elements in the simulation model and take advantage of these elements in case of interaction.

The ontology [Figure1] is a method of knowledge representation and includes areas, such as taxonomy, logical

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properties of the subject area, and the rules of inference. The ontological system is not limited to the storage of information about the MCT, it also assumes its semantic analysis and provides logical inference. The ontology forms a common information space of product flow management. Based on this, competence management is performed by the ontology, which is taxonomy of concepts, supplemented by a number of axioms.

The refinement of these axioms is based on the application of the knowledge representation language. Further, this rule is relevant for logical inference as well. When describing ontology, one uses the first order predicate calculus languages (e.g., KIF, CycL); mathematical logic languages, and computer languages; among them, the most effective is the family of Semantic Web.

To date, the most popular ontological model is the OWL, proposed by the W3C consortium. According to OWL, the ontology O is a description of the classes T owl: Class in the subject area under consideration, as well as properties of owl: Object Property directly for each concept, which describes the attributes A and R. One must take into account the different valid values, which are determined by the domain Dom and limitations C owl: Restriction, which are imposed on the properties.

Fragment F can be formed using arbitrary group of elements of the ontology. In the OWL we can allocate three dialects - OWL Lite; OWL DL (Description Logic); and OWL Full. The level of OWL DL is aimed at the currently urgent systems to describe the knowledge, as well as the systems of logic programming and logical inference, whose purpose is to address the issues, such as:

- Analysis of the ontology correctness,
- Processing query in ontological terminology,
- Ontologies integration and mapping.

The ontological approach is used as the basis for the conceptual modeling for building simulation models for analysis of all flow management processes of semi-finished products. This raises the need for a detailed study of the key concepts in the semiconductor space and in the simulation model. Thus, in the ontology used above, we apply extended description of the subject area of the semiconductor manufacturing.

Classes of the ontology provide the hierarchy – one or more. Each one describes the concepts relevant to the subject area. Over time, the subclasses are added by introducing subsets of a universal set. In this regard, limitations are imposed on them in the form of logical rules. These rules, in turn, can be used in ontological reasoning.

Classes of the ontology often include attributes that describe the properties of the concepts that lie at the basis of classes, as well as their inner structure. These attributes are also present in the derived classes.

Each attribute has its own name, the type of the value, a certain number of values, the constraint of attribute and also widened values.

The type of attribute value includes information about types of values – lines, numbers, etc., in which this attribute may contain. The constraint for each attribute consists in possibility to take not all, but only selected classes.

Data on the relationship between classes and attributes, which are used when storing certain values, should be provided necessarily.

Logical constraints can be imposed not only on classes but also on the relationships, to which logical rules that are used, in turn, at the automated reasoning, can be applied. Describing the relationships, one should define classes, which can be correlated – domain, range of relations. Based on the description of the domain and range of relations one carries out reasoning.

Classes in which values are set for each of the attributes, are part of the ontology. They are referred to as instances of the class. The set of instances of the class together with the ontology constitute the ontological knowledge base.

While working with large ontology, very important are logical inference rules since it becomes possible to more effectively handle the concepts with their help and thus receive new information.

Addition or change of the concepts and rules without reprogramming the new rules gives the possibility to modify the processing algorithms, taking into account the specifics of the semi-finished products flow management at each particular enterprise.

Processing of ontologies provides solution of the tasks, such as the retrieval of information contained in the ontology, through a query and application of the logical inference to existing knowledge.

Information extraction is most effectively done through the access language RDF – SPARQL. It takes RDF data as a set of claims and RDF (Subject, Predicate, Object) triplets.

A more sophisticated mechanism for this purpose is the application of logical inference, coupled with the use of RuleML language. RuleML (Rule Markup Language) language is a subset of the declarative Datalog language;

this extension to SWRL allows one to add and apply a Horn clause to specify the data output from the RDF statements.

When using SWRL, the rules are part of the ontologies. At that, constituent part of the SWRL-Tab is also a part of supply package of the used tool to create and edit Protege-OWL ontologies.

In fact, the rule base is constructed simultaneously with the ontology. It is focused on the knowledge, previously obtained from the experts, i.e. operators and technicians. This is knowledge about situations, actions and entire strategies for the semi-products flow management in the particular MCT. In turn, they can be described with the employment of the above noted approaches.

The application of the rule base and the logical inference module is responsible for solution of such tasks as processing of knowledge about the subject area with simultaneous formation of the source data for the internal structures of the simulation; decision making regarding the course of the simulation and processing and interpretation of results.

There is also possibility of creating several rules databases rather than just one, which describe MCT in different situations, including the emergency situations. The use of knowledge bases gives the researcher the opportunity to adjust the model on the specific situation and carry out the simulation directly in online mode.

Given these data, it is possible to form any rules related to semiconductor production, as well as to control the progress of the simulation modeling.

The use of rules in the process of logical inference produces a synthesis of a program to solve the necessary task; it is selected out of common actions of the simulation system, as well as provides its stage by stage implementation.

This type of knowledge processing procedures is the main component of the scheduler, when simulating the MCT and allows performing tasks, such as the analysis of the situation and making its assessment; development of its solution options, based on the development of the situation; an assessment of each of the possible solutions and choosing the most effective and efficient one out of available options.

Together with the logical inference process, the synthesis of the situation assessment program is performed as well. The situation is then stored until the end of the simulation to the effect that it could be used under appropriate conditions.

The simulation system implements two aspects of adaptation - pragmatic and semantic.

The pragmatic aspect involves the development of a knowledge model in the form of rules at the level of pragmatics, which allow synthesizing data processing programs in the course of modeling and provide structural and programmatic adaptation of the system to a specific subject area or a specific object.

The semantic aspect takes place when developing the ontological model of knowledge at semantic level, whose goal is to describe the objects, interrelations and relations between them, as well as characterization of their class, internal structure, the state model and possibilities of performing certain actions, involvment in various processes and other relationships, such as temporal relations, cause-consequence relations, etc.

4. Conclusion

The use of the ontological approach in modeling of the dynamic behavior of the semi-finished product flows in Multicluster Tools allows creation a set of rules for the classification of knowledge and their subsequent use in a flow simulation modeling. This enables the adjustment of the simulation model to almost any enterprise, MCT and technical processes.

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