# Smart production IT for optimisation of PV manufacturing Lines

The InFrame Synapse product family of German company acp-IT AG offers all the IT functionalities necessary to manage and control a high-tech manufacturing line in the PV as well as semiconductor, electronics and automotive industries. Dr Frank Frauenhoffer, one of the founders of the company, talks about its product portfolio.

**PES:** Dr Frauenhoffer, could you outline your view of the Manufacturing Execution System (MES) in the PV Industry?

**Frank Frauenhoffer:** Looking three or four years backwards, it was very often necessary to explain the value of an MES to PV customers. Nowadays they are asking if the MES includes a Statistical Process Control (SPC) module. This demonstrates a tremendous change, which is presently going on in the PV industry. While in the past almost every product could be sold, nowadays price pressure forces the PV industry to search for higher efficiency to the lowest possible cost. It's clear to me that MES is not the most important key to grid parity. But in order to manage and control an existing PV manufacturing line to the optimum performance and the best product quality at lowest cost in shortest timeframe, MES is an essential tool for manufacturing engineers and management.

**PES:** Do you really believe that all sections of the PV value add chain would need the same MES functionalities?

**FF:** No. It's obvious that a cell-line might need additional other MES functionalities than a wafering or a module line, for example. But a required basic functionality is definitely tracking and tracing, for all of them. That's an absolute necessity for warranty and liability reasons. If I were responsible for a PV manufacturing line, I would not ship any product without knowing how it was produced. All other MES functionalities have to be adapted to the needs of the customer. Therefore a modular MES concept is an absolute must to offer customers a roadmap to implement the modules according to their needs and capabilities, step by step. It would be counter-productive to overload a manufacturing organisation with the full set of MES modules at the same time from the beginning. A step-by-step approach, which has to be defined by the responsible technical and business management, is much more effective. That's one important reason, why we have realised a modular, configurable concept with our InFrame Synapse product family.

**PES:** It's obvious that production data has to be stored for warranty reasons, but why is a MES so important for improving product quality and product cost?

**FF:** In the long term, price and quality will decide the market success of a product in the PV industry. There is a natural learning curve of a manufacturing "system", which drives down manufacturing cost and improves product quality as an effect of experience. There are design limits, which are determined by the product and process design and the manufacturing concept. But, the manufacturing management is able to influence the manufacturing system and to accelerate the learning curve. And this is an important differentiator in the worldwide competition, which you have in your own hands. To learn, react and optimise the manufacturing processes in short time you need data and information, which you will get from the MES.

**PES:** How can data and information help to improve product quality and reduce product cost?

**FF:** It's a matter of fact that in industrial manufacturing you will have failures, even if your product, the processes and the equipments are designed perfectly – and your team is perfectly trained and experienced. Zero failure is a goal and a vision, but not a reality – especially in such a young industry as PV.

However, there is good news. Failures have information available, which will help you to avoid them next time. Failures have a story behind them. You just need to listen. No, that's too simple. You need to analyse like a detective in order to discover the causes for the failure and avoid them next time.

Therefore you need data, which will be delivered by the MES. Manufacturing usually works in such frequencies that you get a lot of data. This means you should use statistics and other diagnostic methods to analyse the reasons for failure. Manufacturing has to select the most important defects first by using Pareto methods. That's what MES is providing. You will get operational data including the point of time a product has been manufactured, by which equipment, with which consumables and durables, by which operator with which recipe and process parameters.

PES: How is this approach reflected in your InFrame Synapse product family?
FF: The InFrame Synapse product family offers to our customers an integrated, modular system, which consist of the "traditional" MES modules contained in the Manufacturing Execution System. In this figure an overview of our complete MES configuration is shown.

InFrame Synapse MES is designed according to the ISA 95 standard, which reflects management and control of product, process and resources in manufacturing as well as manufacturing orders and manufacturing performance. Therefore our MES includes the "traditional" software modules like Resource Management, Tracking Management, Specification Management, Recipe Management, Fab Monitoring and Reporting. Beside that, a number of other advanced MES software modules are provided for Skill & Shift Management, Preventative Maintenance and Experiment Management. A quite important MES module is Job & Dispatch Management, that controls the manufacturing orders on the shop floor and creates "What's next?" lists for the operators or the automatic handling system. With this respect InFrame Synapse MES provides the flexibility to be used either as MES that actively fully controls the process and product flow in a PV manufacturing line. Or it could be configured to simply being just a "listening MES", i.e. just tracking and tracing the production flow – a perfect adaptation according the needs of our customers.

In addition our InFrame Synapse solution comprises a further set of software modules, which we subsume under the name Process Control System.
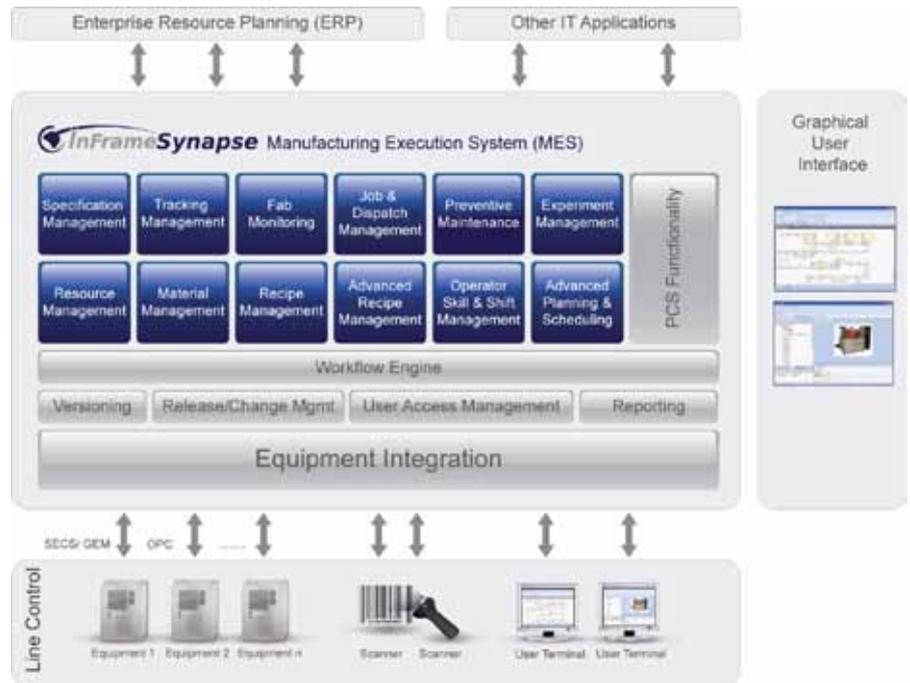


InFrame Synapse Manufacturing Execution System (MES)
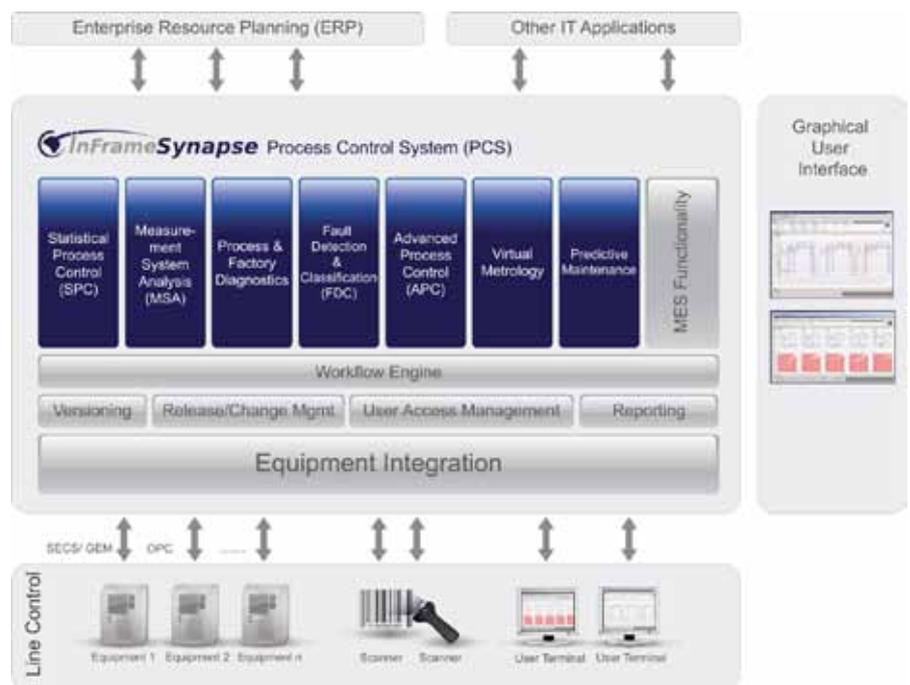


InFrame Synapse Process Control System (PCS)

The PCS contains software modules, which are process parameter-oriented including the powerful yield diagnostics and analysis functionalities.

Using InFrame Synapse diagnostics functionality, process and operational data are analysed, failures are related with alarms, trends and deviations from specification values are identified, correlations and failure hypotheses are found. To verify hypotheses, engineers can run defined experiment lots during normal production with different "special" recipes. If new specification values and process windows have been defined, the Statistical Process Control (SPC) module offers the functionality to control the process parameters within this window. In case a deviation or a trend shifts the process data out of the warning limits, an alarm will be sent to the responsible operator giving him an instruction for corrective action (Out of control Action Plan, OCAP). This might be even done automatically by the system if the correlations are well known.

In summary, InFrame Synapse offers the right set of instruments to support our customers' challenges to reduce manufacturing cost and increase product quality fast and sustainable.

PES: This seems to be a wide set of functionalities of IT tools for your PV customers. But what are the non-functional advantages of your InFrame Synapse solution?
FF: InFrame Synapse is a Web-based solution guaranteeing scalability for extension and upgrading the manufacturing line with new equipments. It's a state-of-the-art system architecture (Service-Oriented Architecture, SOA), open for extension with well-defined and documented interfaces.

> It's natural to couple simulation and MES for a manufacturing line, where the MES is controlling the production flow

Usually, customers like to do reports by themselves without the need of help by the MES supplier. InFrame Synapse provides this as a standard. But often they are requesting to change the customised elements of the solution, if they need to. InFrame Synapse is using a workflow engine within its core architecture. Using the workflow engine the customers are able to adapt their business processes in the MES by themselves. It is even possible, that they develop their own customer-specific modules.

In order to control changes of MES master data like process specifications and parameters, equipment descriptions etc. we have integrated a Change-and-Release Management in our solution. This means that the history of all changes is documented and changes have to be released by

a release process and workflow. If you have ever been responsible for a complex manufacturing process you can immediately understand the value of this feature.

PES: Your team has lots of experiences in Production IT for the semiconductor industry. Is this knowhow transferable to the PV industry?
FF: Yes and no. I would say PV has a different manufacturing complexity. Compared to semiconductor manufacturing with its complex manufacturing processes, its huge number of products and huge data amounts, PV manufacturing is surely simpler. But in PV manufacturing there are also high production volumes and fast production processes with cycle times <1 second, that result in quite high performance requirements and real-time behaviour for the MES. Nevertheless there are many methods and principles to be transferred from SC to the PV industry.

For example the standardisation is a key element, where PV has to learn fast from SC. In fact within the SEMI EIS workgroup a big step has been done to standardise the equipment interfaces. This was not a one-to-one transfer of the semiconductor standard to PV. The working group was well aware that the well-established standard in SEMI had to be adapted to the needs and the cost structure of the PV industry.

If in future the ramp-up of a PV manufacturing line has to be completed within a timeframe smaller than two months, as Anton Millner (former Head of Q-Cells SE) requested already some years ago, there is no way without standards. A MES implementation and the integration of the equipments in a PV line have to be done as a plug-and-play solution, no doubt about that.

We are following that direction from the beginning by actively participating in the SEMI EIS group and by introducing our PLC-SECSII Connector into the market end of last year.

PES: Could you please outline in more detail?
FF: One hurdle for the acceptance of the SEMI standard is that the equipment suppliers have to build up SECSII knowhow in their teams to learn how equipment can be connected to an MES in a standardised way. In order to facilitate that, we have designed our PLC-SECSII Connector. This is a piece

of software, which can be configured by the equipment suppliers in their well-known PLC world and provides a standardised SECSII interface for the equipment. On the MES side InFrame Synapse already provides this standard connectivity. Equipments, that use our PLC-SECSII Connector, can be integrated to our MES solution seamlessly with no additional effort.

PES: Would the usage of the PLC connector be sufficient to guarantee a plug-and-play MES solution?
FF: Naturally, that's just one important step in the right direction. Our goal is to finally build a digital model of the PV manufacturing line and simulate that line together with the MES.

The first step is that we simulate the line logistics using our InFrame Synapse Simulation suite. That's a library of PV equipments and simulation objects which we are successfully using for the simulation of thin film, cell and module lines. These projects are typically performed together with the industrial engineering teams of our customers to verify and optimise the line concept, capacity, throughput, production logistics, maintenance strategies etc. Building up the simulation model we have to define the resource model and we are using the process flows of the products within the manufacturing line. But this is also basic data for the MES. It is obvious to use the model data within the simulation also as an input for the MES. And it's natural to couple simulation and MES for a manufacturing line, where the MES is controlling the production flow – which is anyhow the trend in highly-automated PV manufacturing lines. Therefore we are able to already test the MES with all the process flow and the equipment used, prior to the ramp-up phase. That's a big step to plug and play. The next step is the emulation of the equipments in this virtual model. We are already working in that direction. ■