Sensor Integration Concept for APC

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plasma metrology experience

Concept for APC - Overview

- 1. Data Reduction by Sensor Integration
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  - Fundamental APC data concept
  - Real-time data compression
- 2. Variation of Equipment Coupling of Sensors
  - Motivation of Equipment Coupling
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  - LAM – pnp – Sensor Interface
  - Silverbox
  - Comparison of Data Cpoupling

Concept for APC – Overview cntd.

- 4. Sensor Actuator Network with Modbus
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  - Properties of the S/A Network Controller
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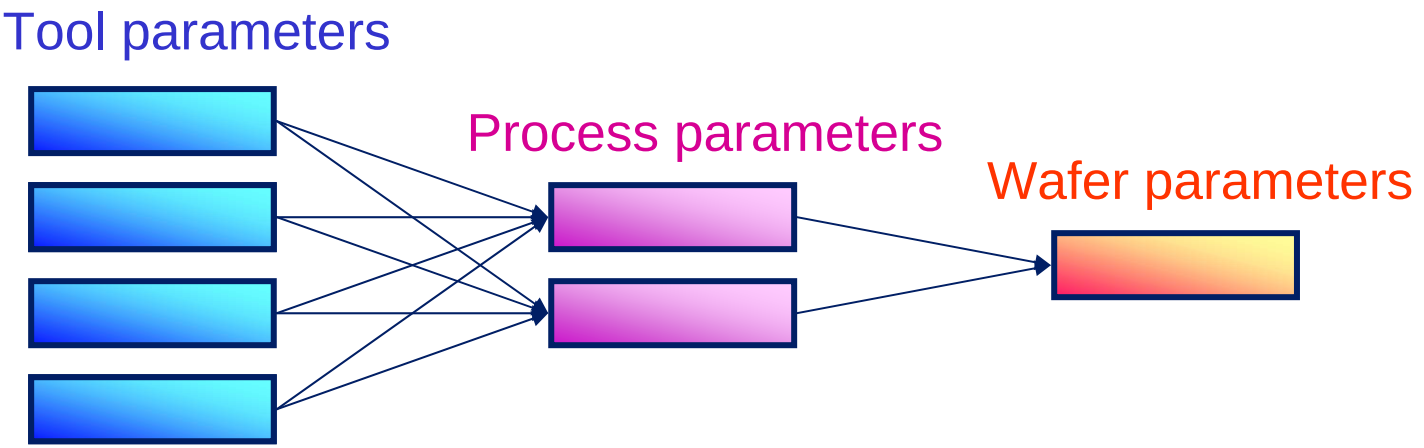
Tool and process parameters

- Measurement of complex parameters

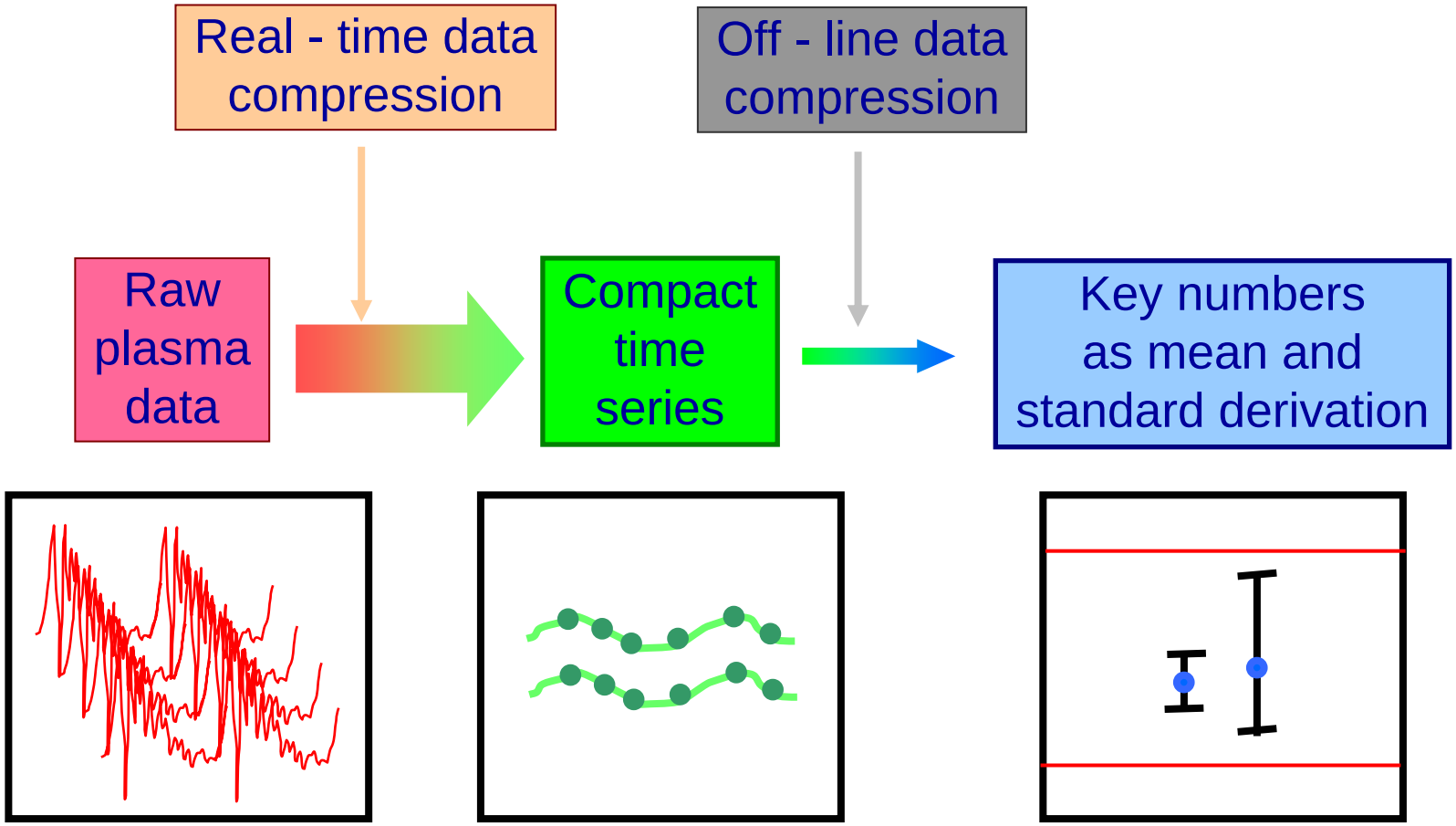


- Monitoring of complex process parameters, indicating tool and wafer conditions (e.g., endpoint time or plasma parameters) reduce the number of parameters, checked regularly.
- Stable values of these complex process parameters indicate stable process condition.
- In case of process variations additional analysis of tool and wafer parameters is needed to identify the reasons in detail.

U. Nehring, et.al. (Infineon Dresden), 2nd Workshop of SEERS, Dresden, Germany, 2000.

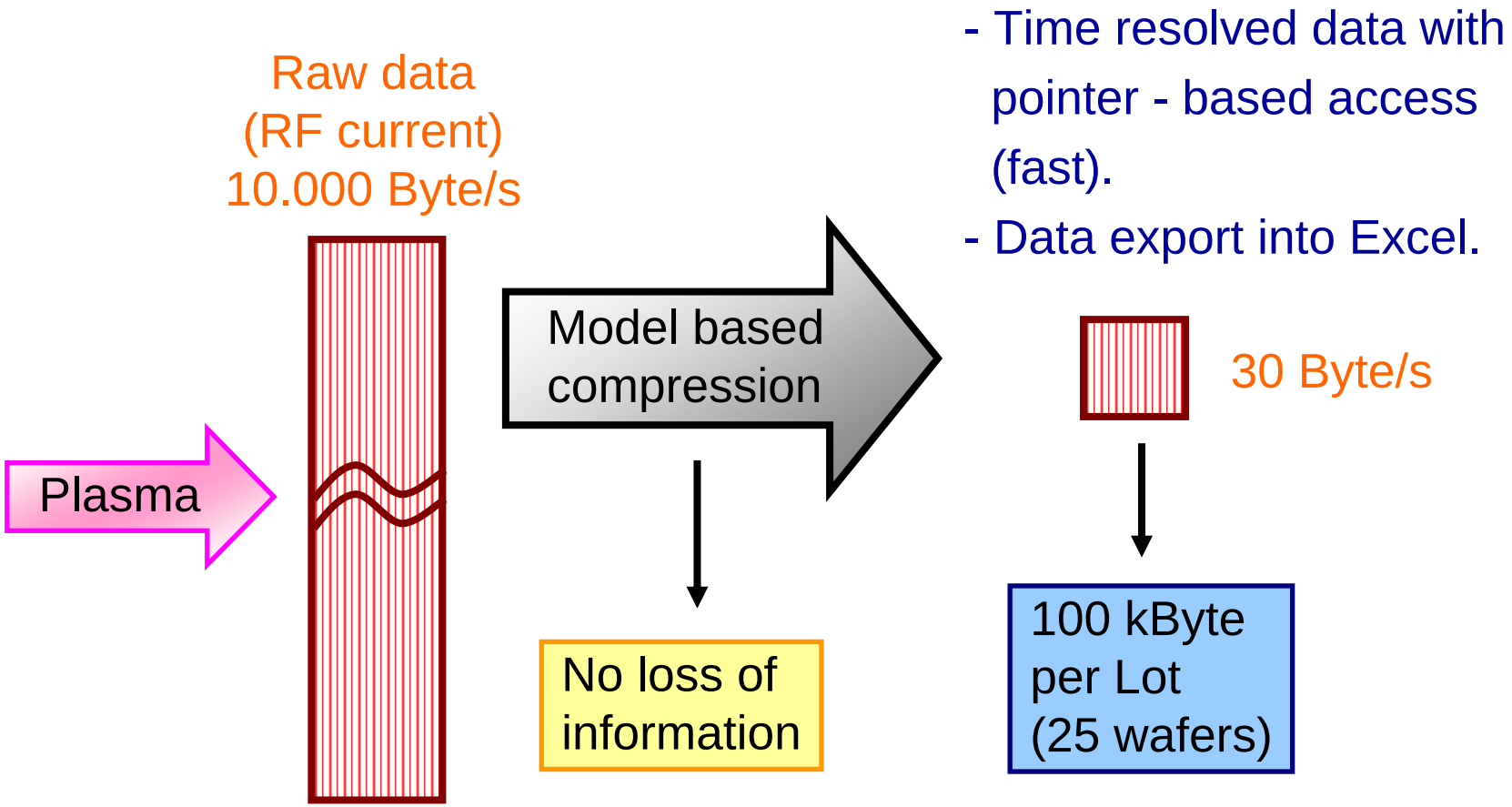
Fundamental APC data concept

- Two step data compression



Real-time data compression

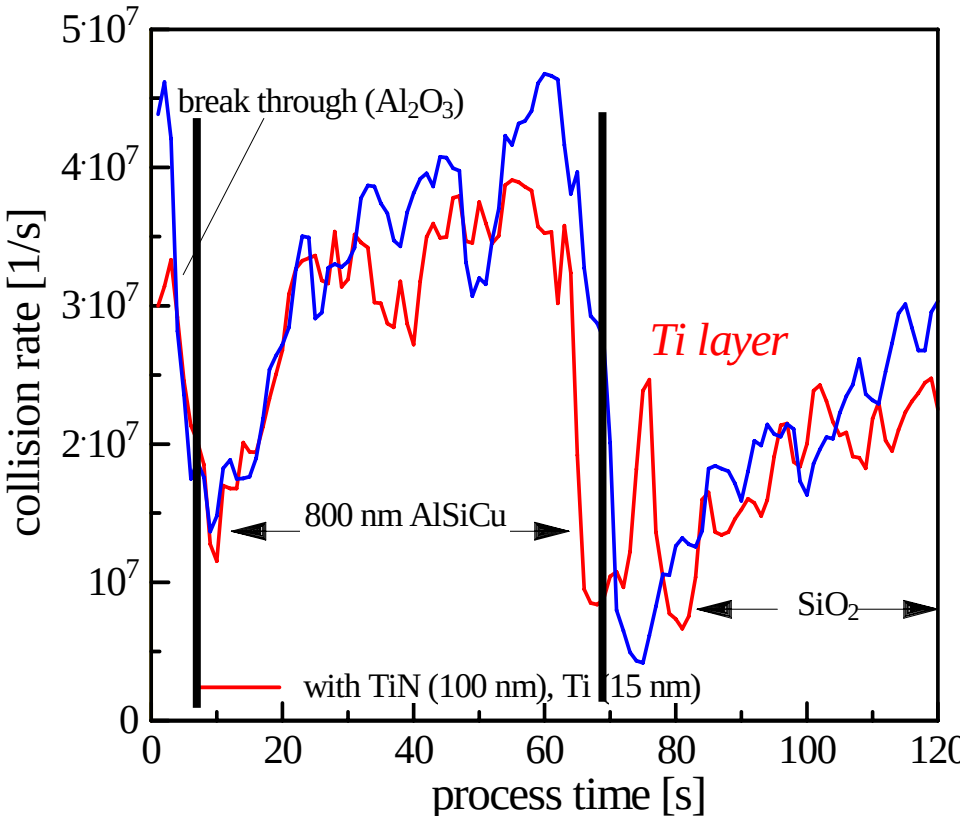
- Data compression of physics - example



- Time resolved data with pointer - based access (fast).
- Data export into Excel.

Importance of Step Information

- Time resolved sensor signal



- Mean of each recipe step is different from the mean of the whole process!
- All analysis has to done separately for each step.
- Artificial time shift of the step start and stop mark force change in mean calculation. →
- Exact step information is very important.

Motivation of Equipment Coupling

- Link logistical data (LotID, ToolID, Step, etc.) to sensor data.
- Unification of data streams of the tool and the sensor.

Sensor is coupled with the tool.

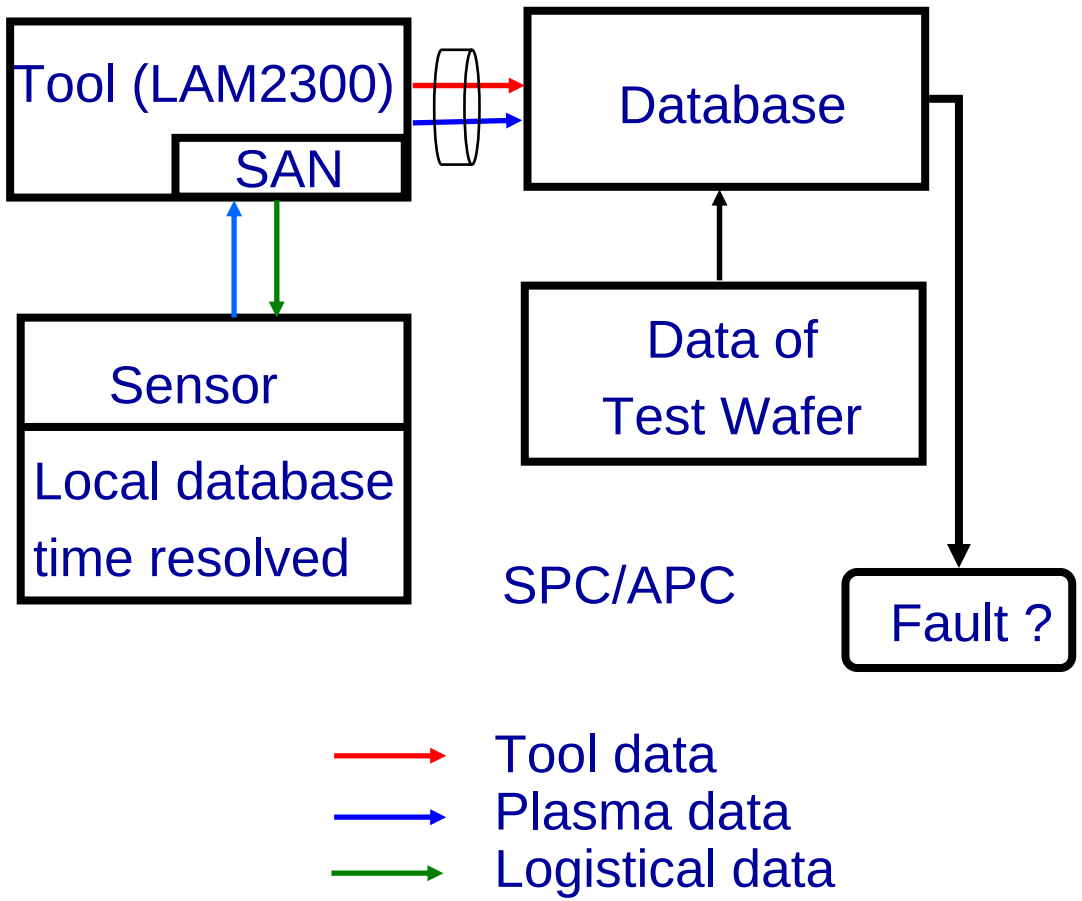
Fault detection and APC possible.

Equipment coupling
- The basic requirement for APC and fault detection.

Add-On-Sensor
- Necessary to get process relevant data.

Best Solution for Sensor Integration

- Key numbers of plasma and tool data



SAN integrated in the tool:
- Unification of data streams in the tool.
- Only key numbers of relevant data are stored
  → data compression!
- In case of detected fault time resolved data for deeper analysis.

ADVANTAGE:
Plasma data integrated in the tool data

SAN: Sensor-Actuator-Network

Cost Reduction by Sensor Integration

Now:

Manuel data handling - high man power needed

Sensor network - fast access to process data.

Standard sensor interface - fast and easy Implementation of sensors.

Cost and man power reduction

automatic data analysis.

*Low **CoO** (**C**ost **o**f **O**wnership).*

Equipment Coupling Concepts

1. SECS
2. Brookside´s Sensor option
3. TICS (Infineon-Standard) one way connection, only logistical data
4. Data transfer using analog interface
5. LAM - pnp - Sensor Interface
6. Silverbox
7. Sensor-Actuator-Network: Modbus

SEMI-Standard E54

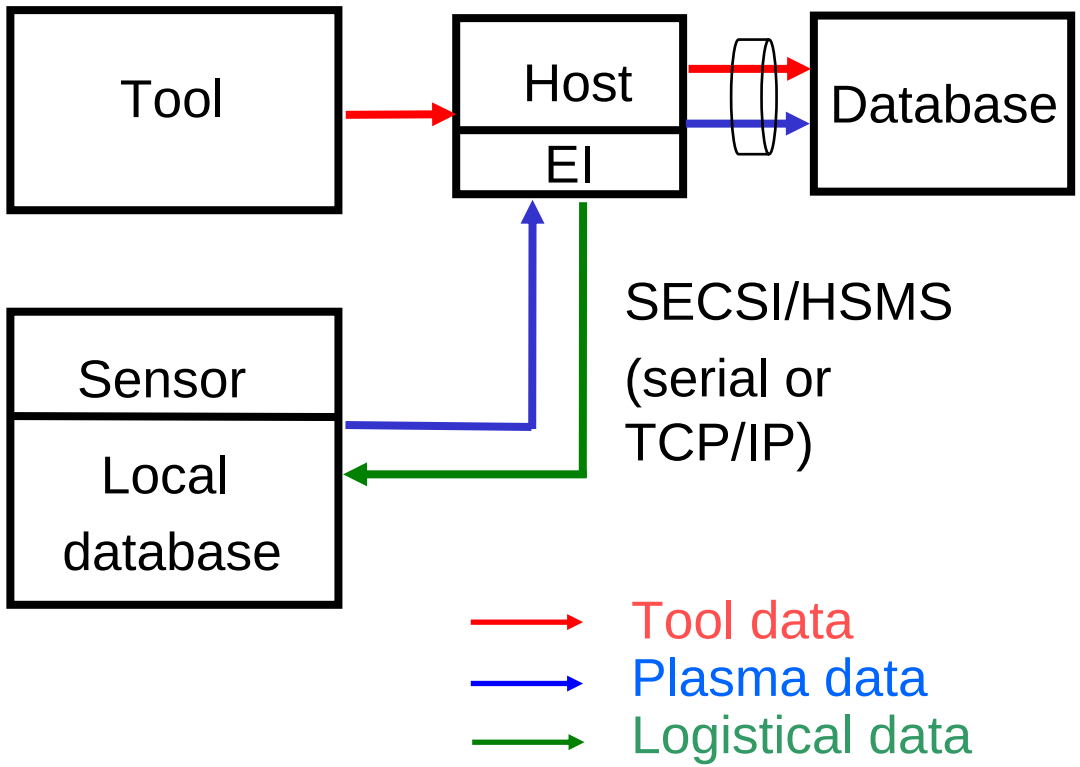
- Modbus/TCP is one of 6 possible network communication standards.
- SAN is not yet implemented in the etch-tools

→has not found wide application yet.

SAN: Sensor-Actuator-Network

SECS II

SEMI Standard E5 a few commands supported, not GEM compliant.

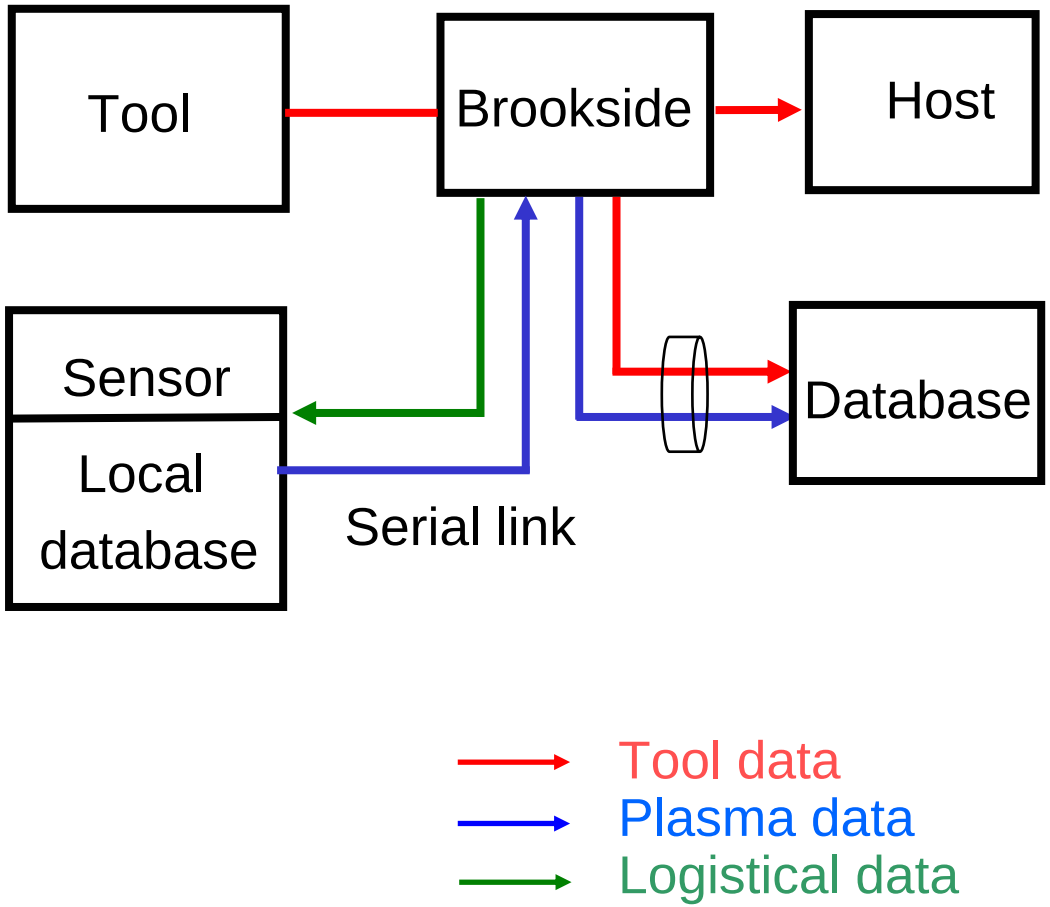


- For each sensor one **E**quipment **I**nterface (**EI**).
- Transfer of sensor data by data tracing.

PROBLEMS:
- Data unification.
- Step information delayed.
- Time synchronisation of tool and sensor to reduce delay.

SAN: Sensor-Actuator-Network

Brookside´s Sensor Option

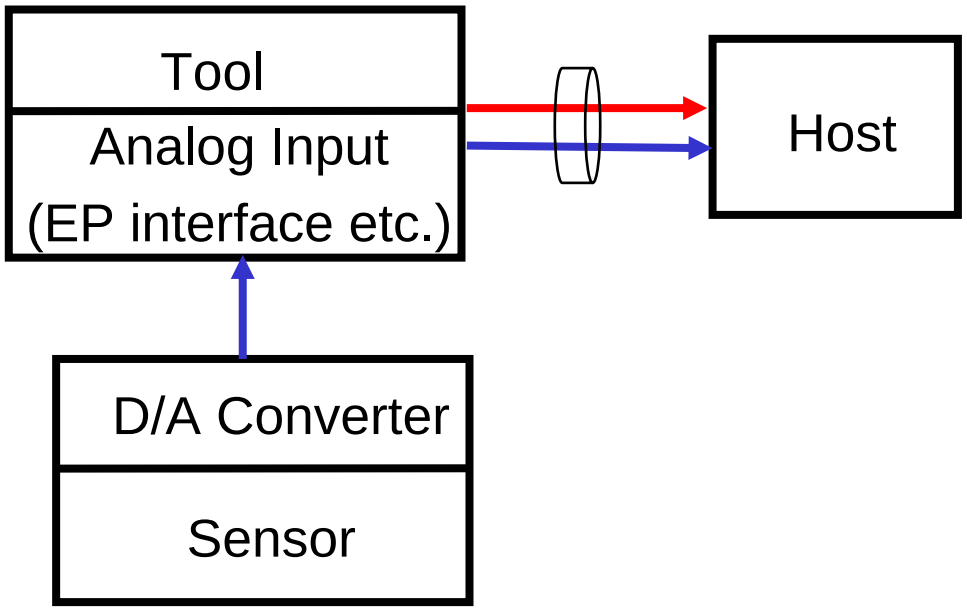


Data exchange, e.g. , via Brookside´s 'Hercules® interface'

- Step information included.
- Brookside contains all tool data and plasma data.

ADVANTAGE:
Fast and easy implementation

Analog data interface



- Data unification in the tool.
- Tracing of plasma data via SECS-Interface of the tool possible.
- Quick and easy implementation.

DISADVANTAGE:

Restricted resolution.

Data range is limited.

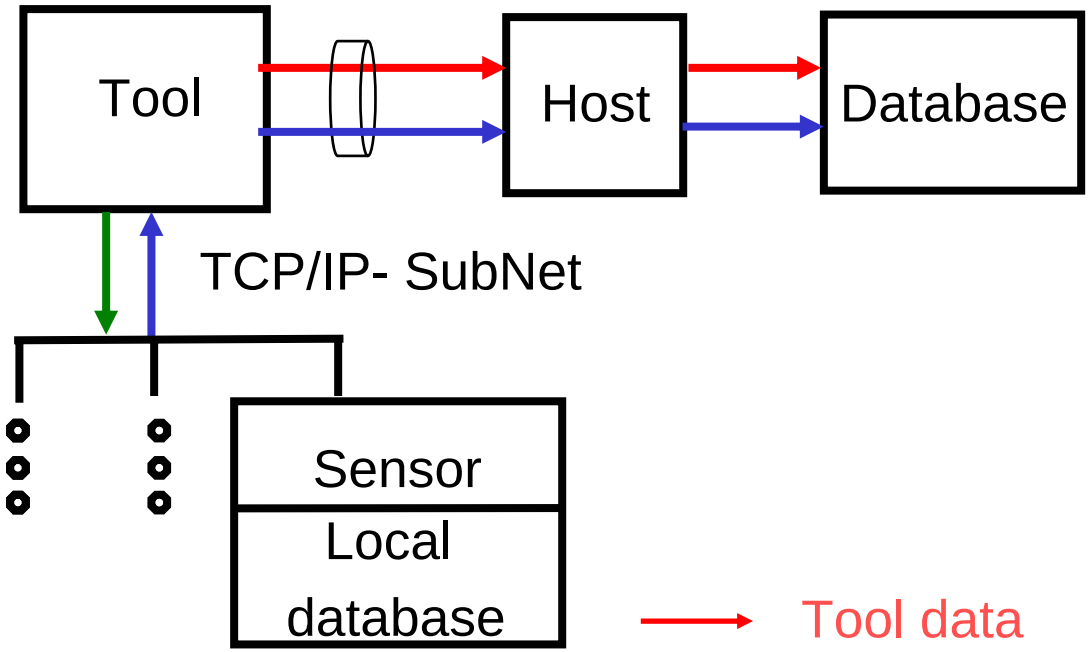
Tool data

Plasma data

Logistical data

LAM - PnP sensor interface

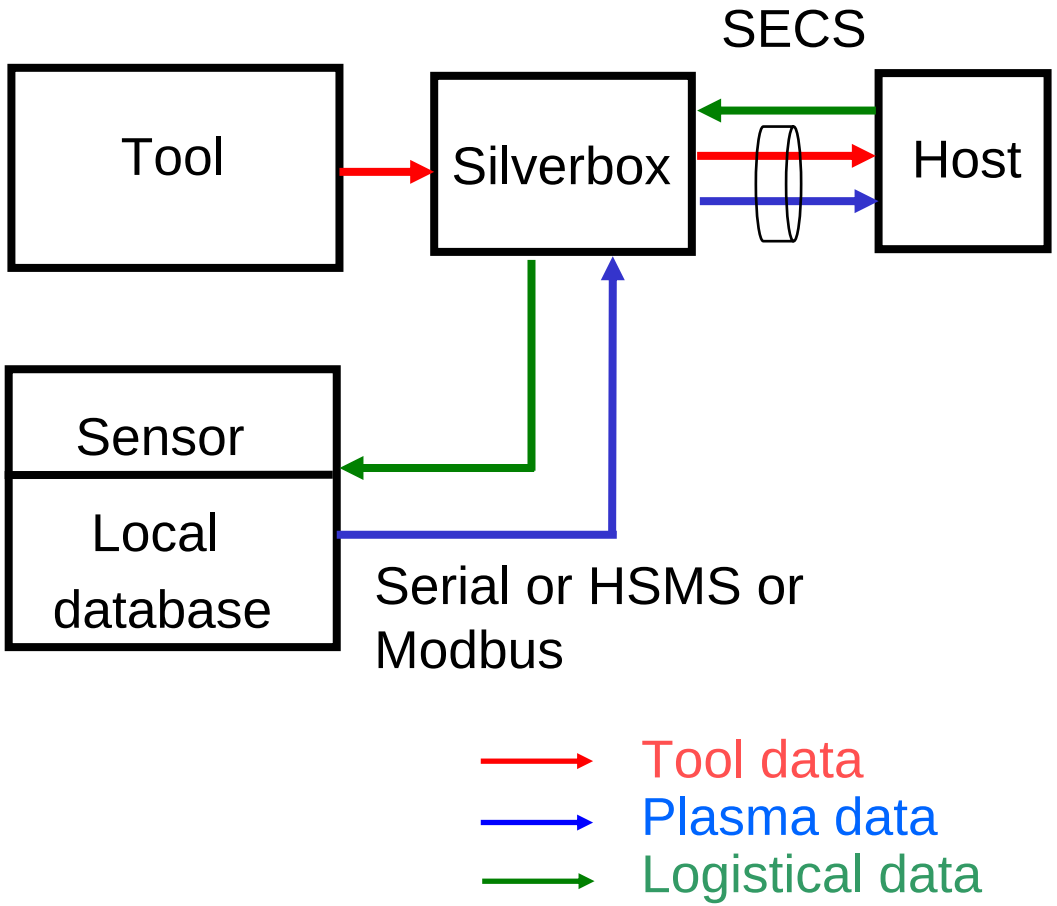
Plug and play sensor interface.
First implementation of a sensor interface into a tool.



- Similar to the SAN.
- Best available solution for sensor integration.
- All data are unified in the tool.

Silverbox or other

SECS-path-through with sensor interface

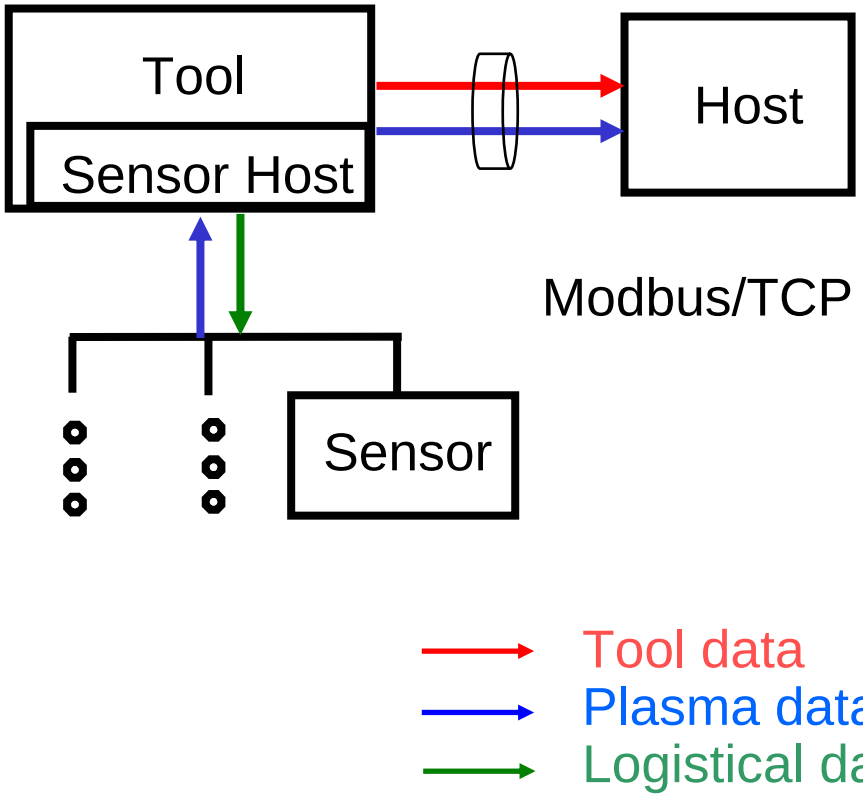


'SECS-relay' with integrated sensor interface.

- Pre-filtering of the data possible.
- Supports more than one sensor.
- Easy implementation.

SAN (Modbus)

Modbus SEMI E54



Common Network Communication Standard (NCS): TCP

- More than one sensor.
- Plug and Play.
- Link to tool data including logistical information.
- Data unification in the tool.
- Will be Modbus the solution of the future?

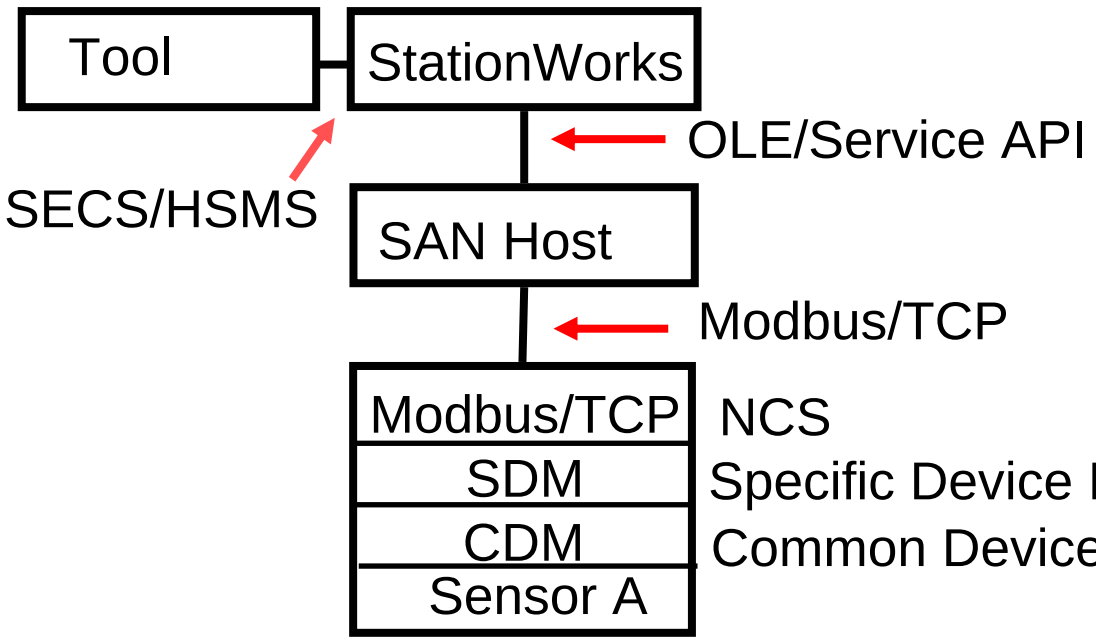
Comparison of data coupling

	Logistical data	Step information	Plasma data transfer	Recommended
SECS	x	x*)	x	(x)
Brookside	x	x	x	x
TICS	x	x*)		
LAM-PnP	x	x	x	x
Silverbox	x	x	x	x
Analog Interface			x	
Modbus	x	x	x	x

*) temporal delay

Sensor integration at Station Works - Modbus

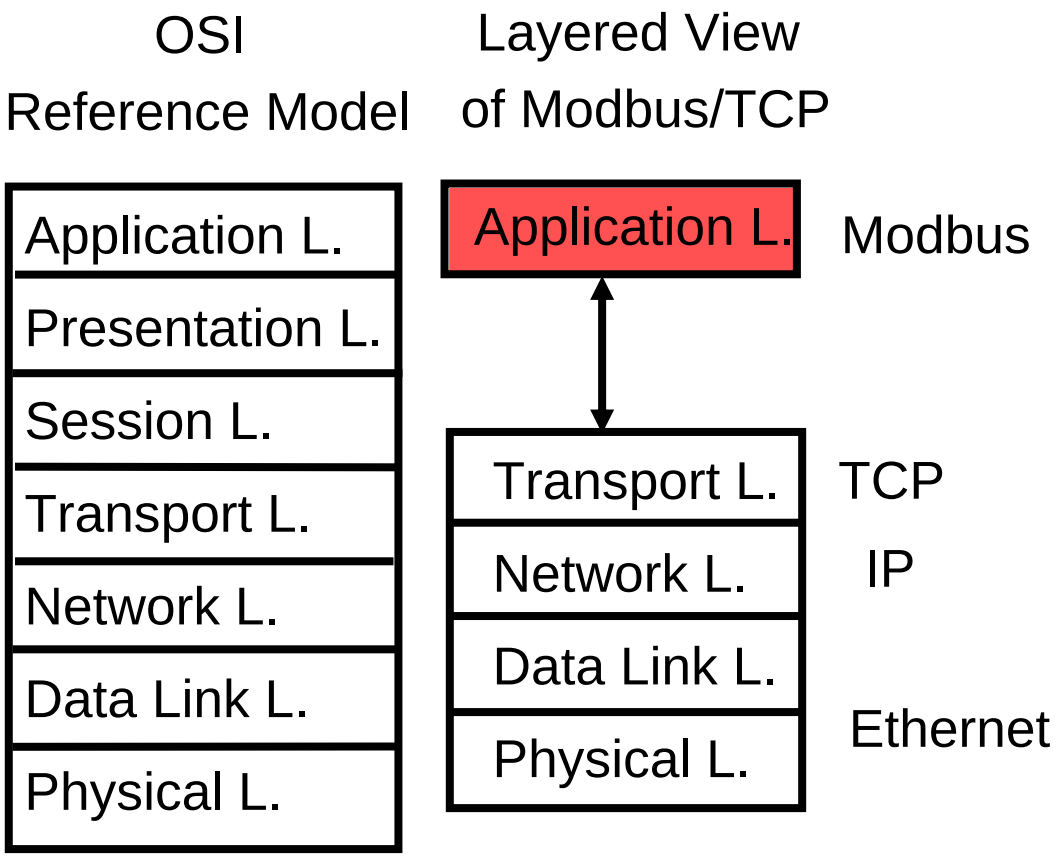
This model is conform to the SEMI standards
Example with external sensor host



Microsoft/Brooks uses „StationTool“ to implement sensor host.

SAN: Sensor-Actuator-Network, NCS: Network Communication Standard

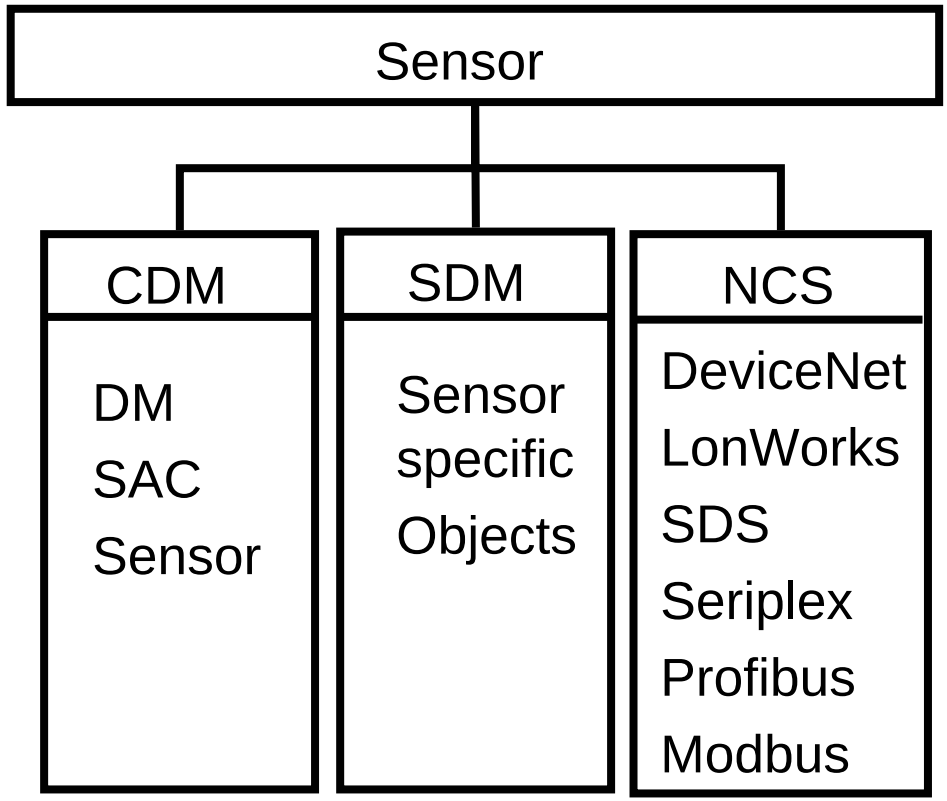
OSI Reference Model Modbus/TCP over TCP/IP



- Only integrate the Modbus Telegram into an TCP/IP message.
- Easy to implement:: Call Socket API and insert Modbus Tele-gram.
- Only changes in application layer.

Standard SEMI E54 - Sensor Actuator Network

- Model of a Sensor Object



Defines objects, methods and attributes common for all sensors in CDM.

Object-oriented design

CDM - Common Device Model

SDM - Specific Device Model

NCS - Network Communication Standard

DM - Device Manager

SAC - Sensor/Actuator/Controller

Common Device Model SEMI E54.1

- Example Device Manager Object

Device Manager Object (DM) *)	
ClassID=1, InstanceID=1	
Attributes	
ID	Attribute Name
01	Device Type
02	Standard Revision Level
03	Device Manufacturer ID
12	Exception Status
Services	
ID	Service Name
01	Reset
07	Get Attribute
09	Set Attribute

Adressing via Object Messaging possible

Example:

DeviceManager.Get.Exception Status

→ Modbus/TCP Telegram

Sub Field of Massage Data (hex):

09 00 00 0100 0100 07 00 12

Byte0 Fragment Byte Count

Byte1 Fragment Protocol

Byte2-3 ClassID

Byte4-5 InstanceID

Byte6-7 ServiceID

Byte8- Data N*16

***) not complete**

Properties of the S/A Network Controller

Requirements of external SAN controller (host):

- Interface to the equipment software.
- Provide plug and play functionality.
- Time synchronisation.
- Logistical information.
- Scenarios for establishing communication and data exchange.
- Testing connection.

Properties of sensor host not defined in SEMI standard.

Additional Items of **S**pecific **D**evice **M**odel

The experiences show - SDM has to be extended by attributes related to the process:

- LotID
- WaferID
- Recipe name

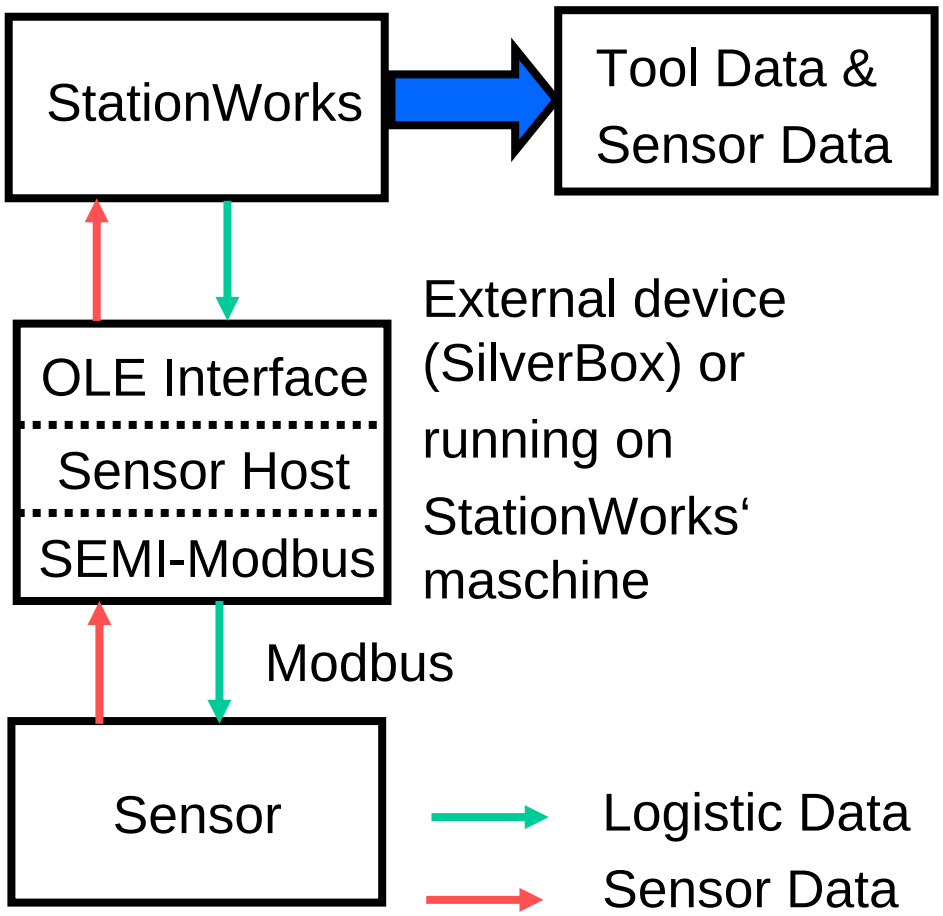
Alarm events
Endpoint detection
Sensor database

Additional services to avoid temporal shift:

- Time synchronisation.
- Get data with time stamp.
- Connection check.

Implementation of Modbus sensor network

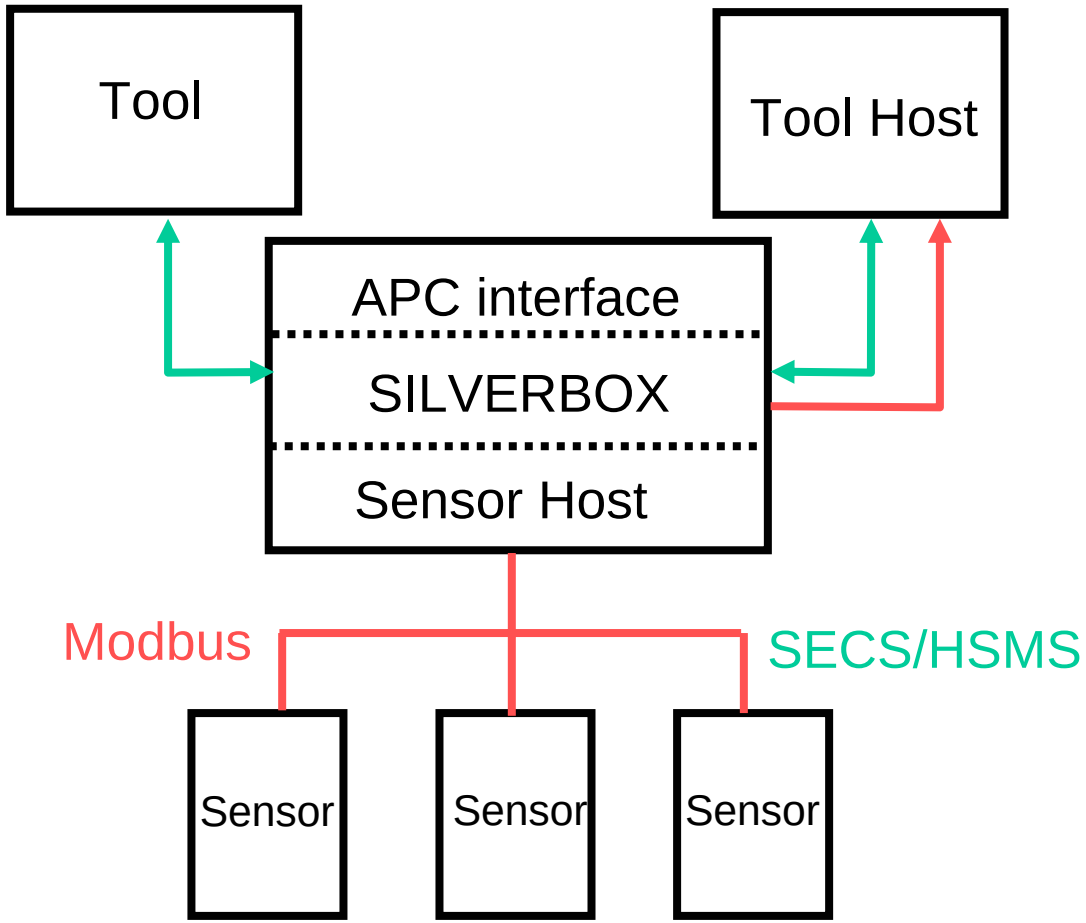
SEMI Standard E54
- External Sensor Host



- Create new service within StationWorks with the help of StationTool.
- This service has a interface to the sensor host via OLE.
- Implementation of the sensor host:
  Establish communication to sensor.
  Get Sensor data.
  Send process start and stop.
  Send logistic information (LotID,...).
  Perform connection check talks Modbus to sensor.

Implementation of Modbus sensor network

Silverbox is a SECS-path-through devices



- Sensor data added to the SECS - stream.
- Tool host and APC-interface only see one data stream, with tool and sensor data.
- Automatic data analyse by using standard tools via APC-interface.

Comparison of sensor network solutions

	Modbus	Silverbox	LAM Plug & Play
Time stamp	Extend SDM	-	yes
Logistic data	Extend SDM	yes	yes
TCP/IP	yes	yes	yes
Data unification	-	yes	yes
Already available	no	yes	yes
SEMI standard	yes	yes	no
Data interface	Stationworks	FDC model	SECS II

Comparison of sensor network solutions

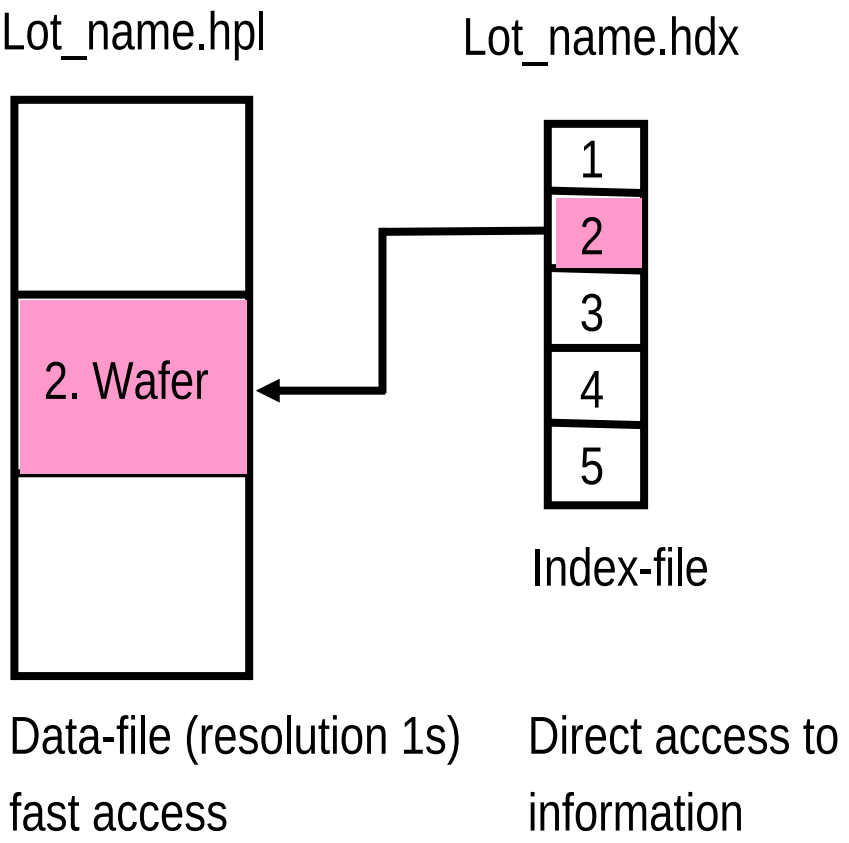
LAM Plug&Play for LAM 2300 recommended
(is already running).

Fastest implementation of the sensor network will be achieved with the Silverbox. (except LAM2300)

Modbus needs sensor host with interface to MES
(e.g., Station works).

Example of local data base

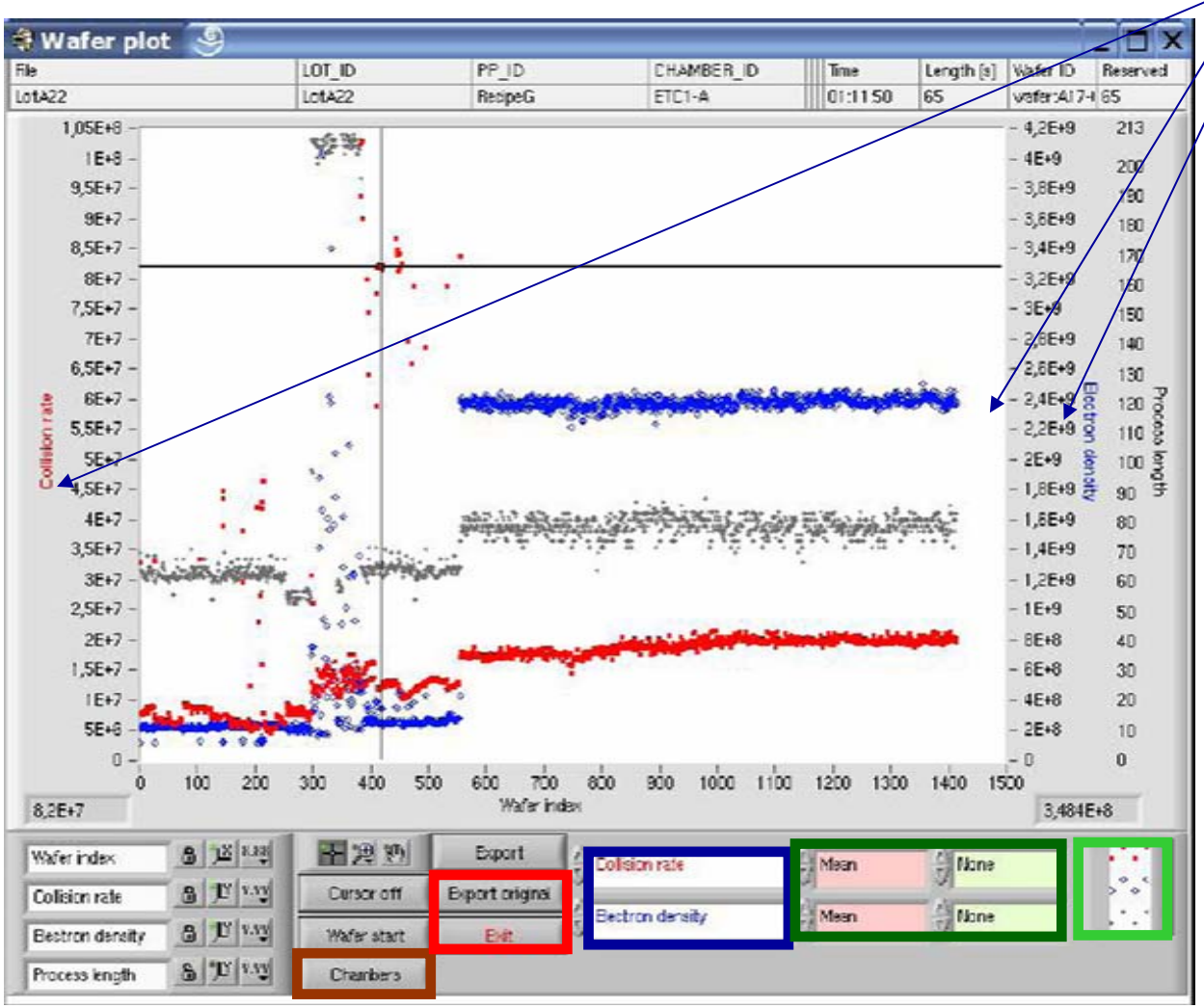
Structure of Hercules® data



Pointer based byte format:
- Data compression (for time depended raw data, ASCII is not recommended).
- Fast access.
- Easy unification of plasma data of different sources.
- Data selection by logistical data.
- Export to ASCII/Excel

Local solution is important for:
- Backup.
- Deep analysis in case of faults.
- Time resolved data.

Data visualization with HercLotView



2 parameters and process length are shown as selected below.

Selection: wafer number or start time.

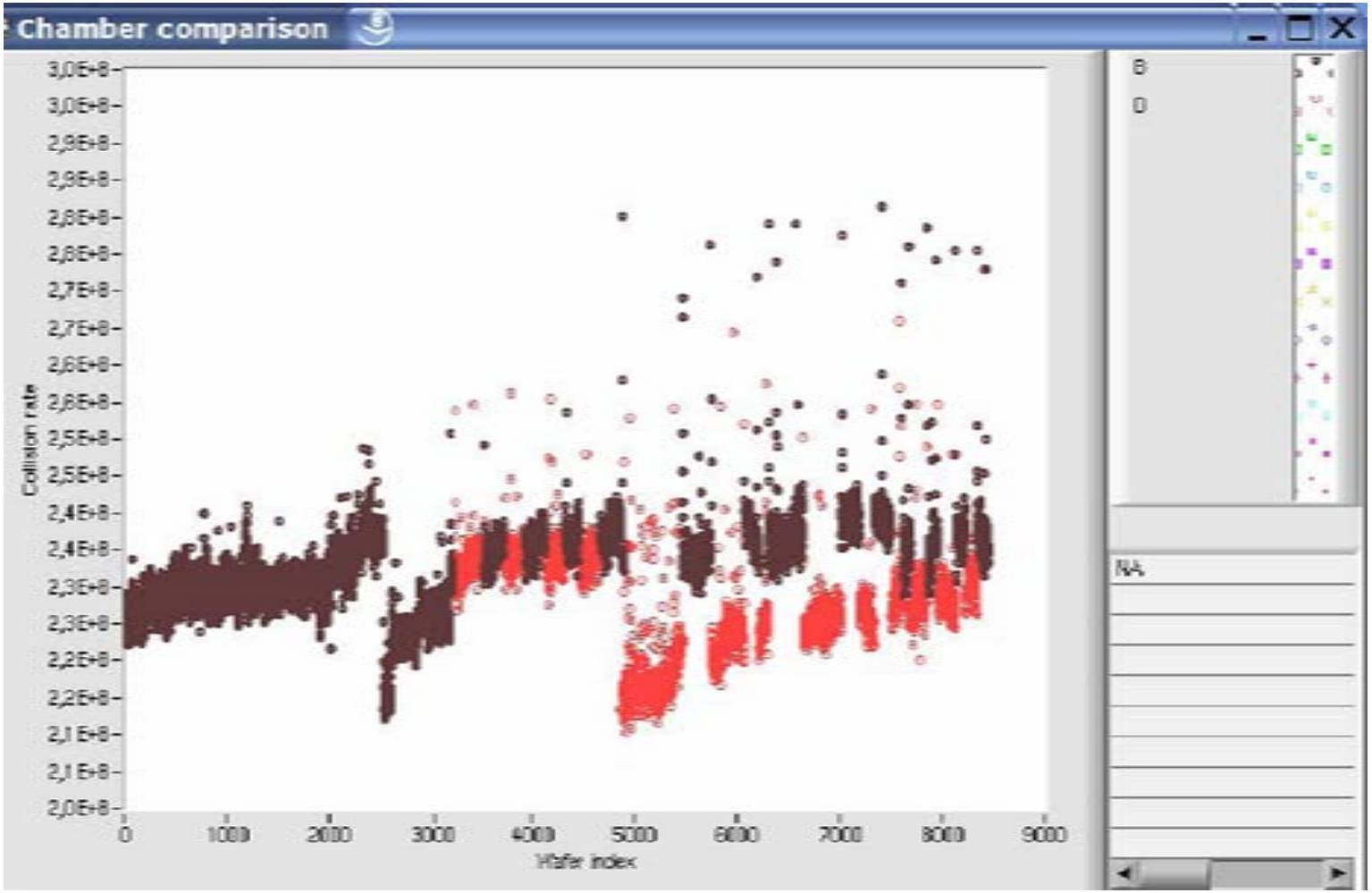
Export all (=original data as an ASCII-file.

Mathematical and statistical operations.

Several options for formating symbols.

Chamber comparison with HercLotView

- The diagram shows the electron collision rate of chamber B (brown dots) and chamber D (red dots).



Summary

- Additional sensors are necessary for a more effective process control and fault detection.
- A standardised interface is an important requirement to:
  - Transfer sensor data and logistics (Lot ID, etc.).
  - Unify tool data and sensor data on the same time base.
  - Create the basis of automatic data analysis.
  - Easy integration of additional sensors (Plug and Play).
- Ethernet/IP (SEMI E54.13) has been found to meet all requirements on the communication protocol from practical view.
- The common objects of ICP include all necessary properties. No further specific objects or attribute have to be defined, i.e. the master of the SAN must not know specific properties of all sensors (great advantage!).
- The interface has to be integrated in the production tool.
  - E.g., gateway DeviceNet – Ethernet/IP.
  - 'Box' as SAN controller.

Reference: Dirk Suchland, Sensor Interface based on Ethnet/IP as Network Communication Standard – SEMI E54.13, 5th European AEC/APC Conference, Dresden, April 14th – 16th 2004