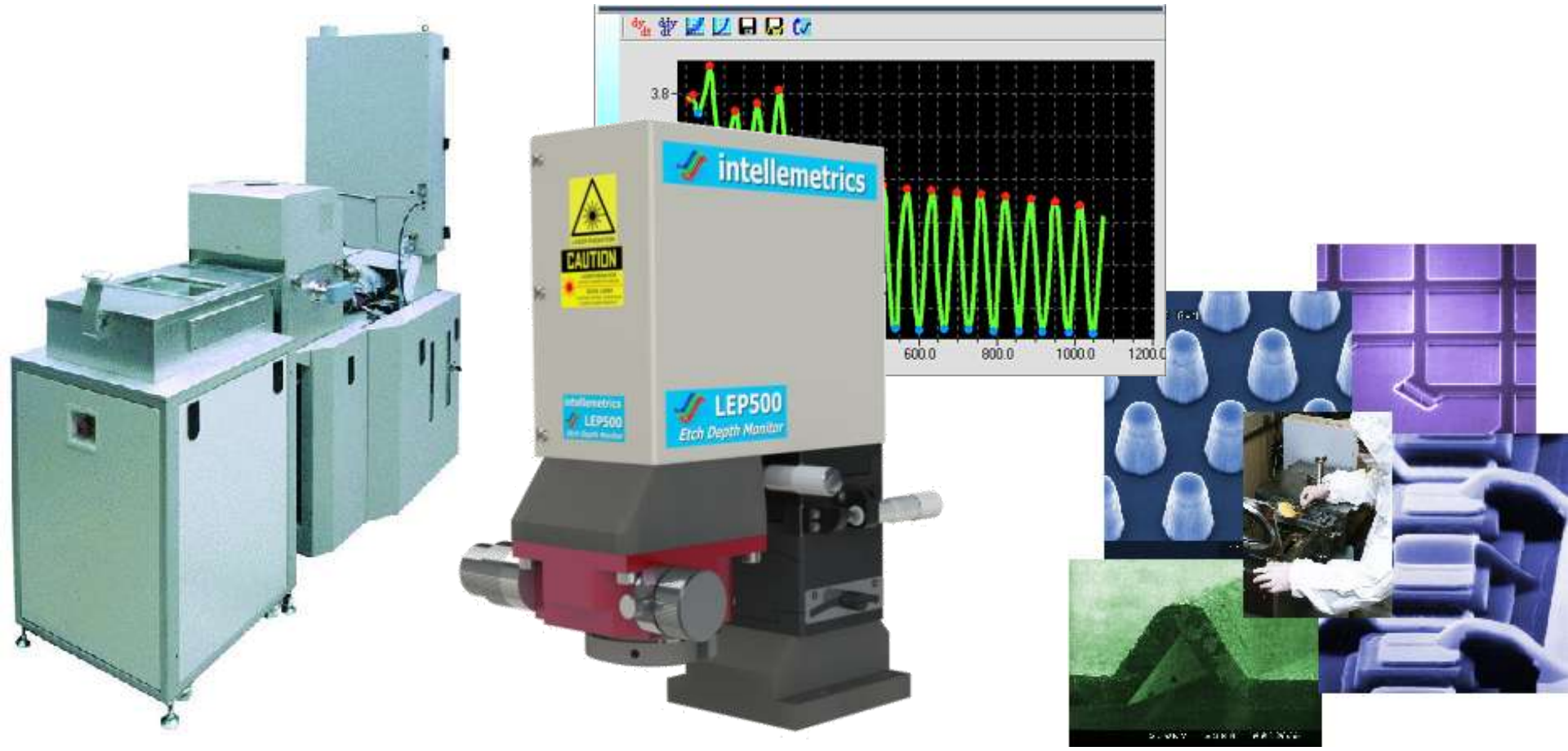
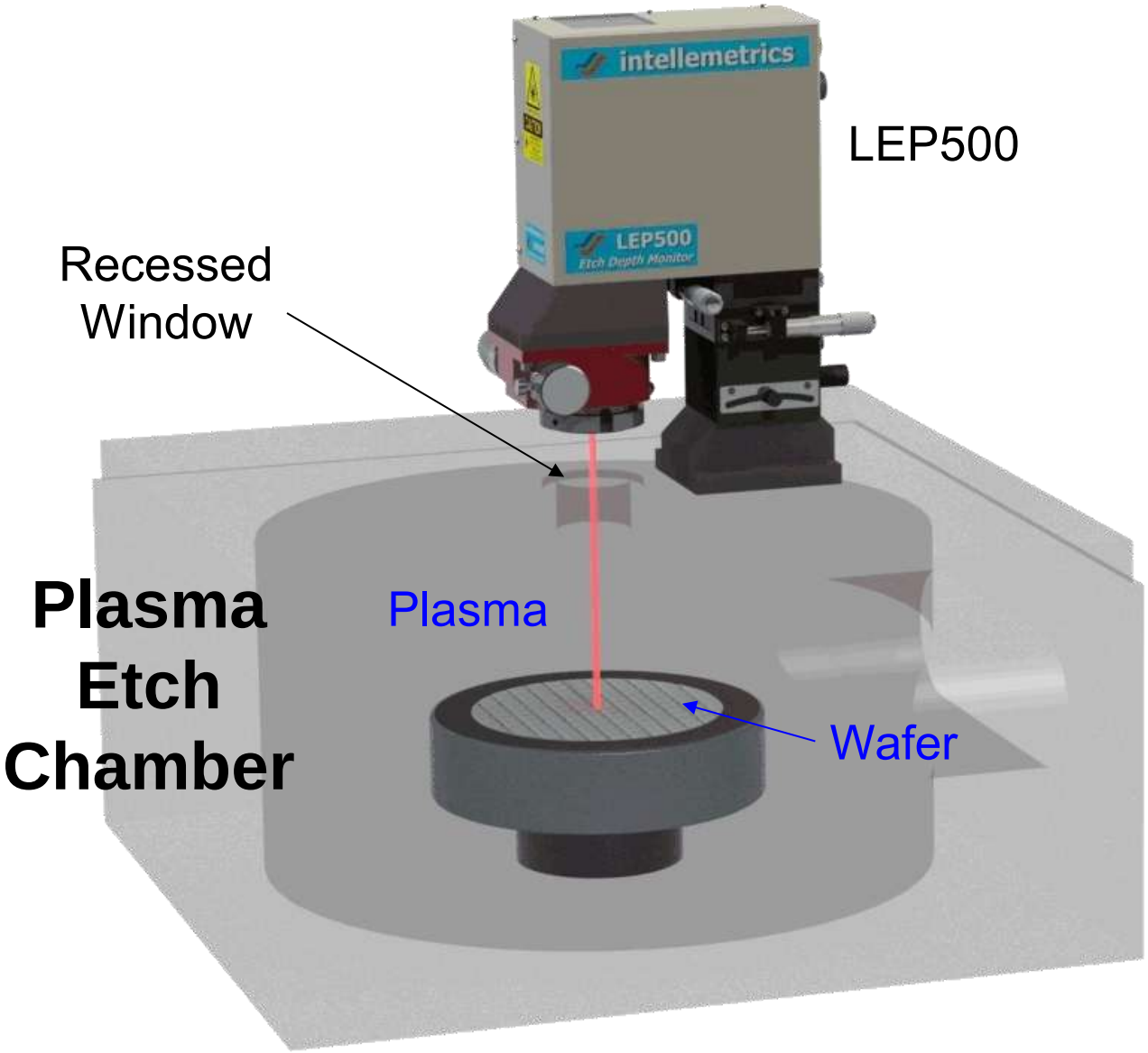
LEP500 Etch Depth Monitor

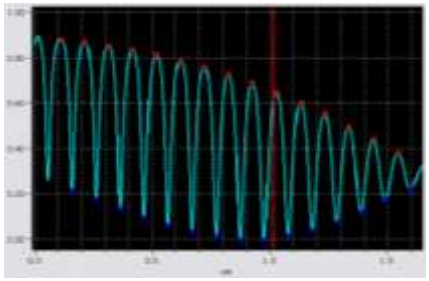
Real-time, in-situ plasma etch depth monitoring and end point control plus co-linear wafer vision system

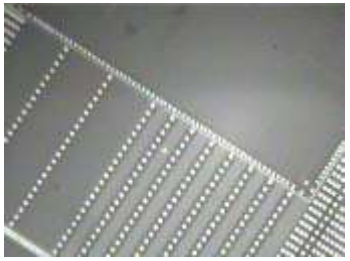


Base Configuration



Etch Depth Monitoring



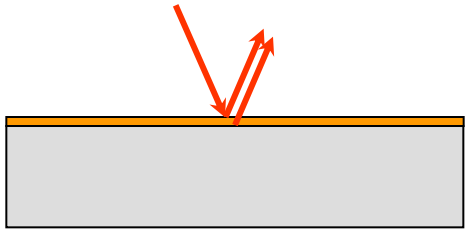


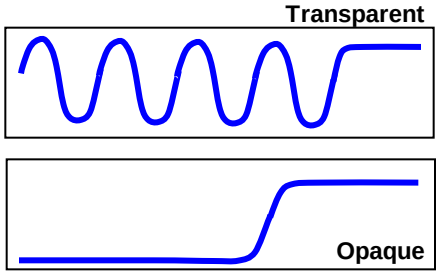
Laser Spot on Patterned Wafer

Principle of Operation – Reflectometry & Interferometry

Useful in a wide range of environments……

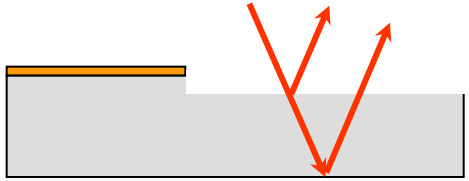
- Surface Layer Removal

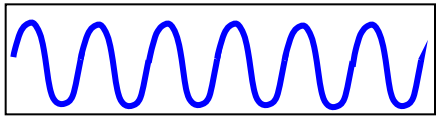




- Bulk Material Etching

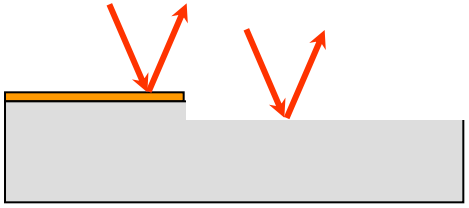
  Signals from etching surface and bottom of wafer

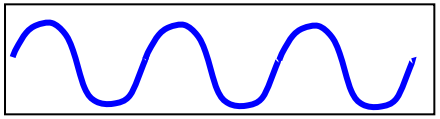




- Bulk Material Etching

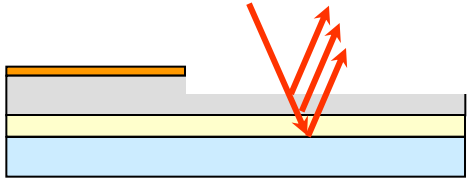
  Signals from mask and etching surface of wafer

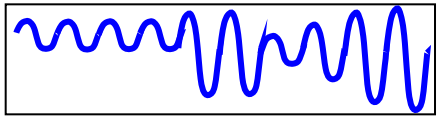




- Wafer Stack Etching

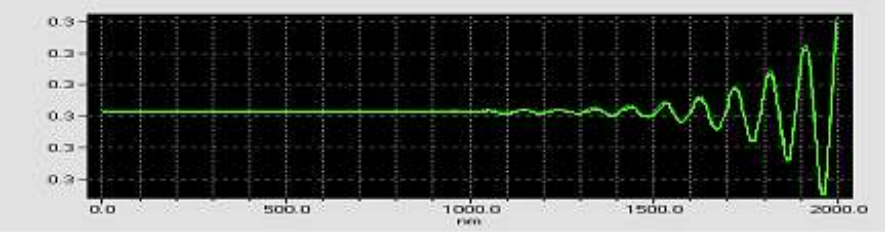
  Signals from etching surface and every other interface of wafer stack



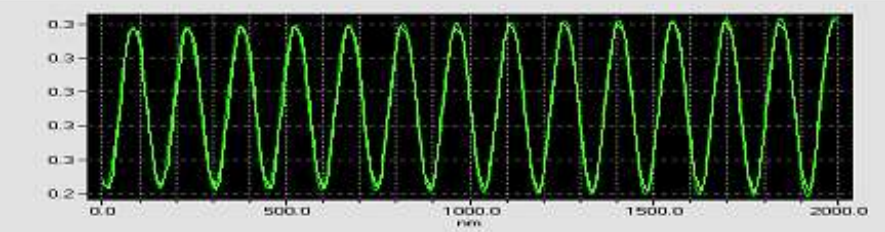


Importance of Wavelength

- Monitoring InP at 670nm
  - Fringes seen only when layer is thin
    ~ 700nm



- Monitoring InP at 980nm
  - Clear fringes throughout



- Figure of Merit Maximum Measurable Thickness for Different Materials & Wavelengths

Wavelength	Material	Max Depth Measureable
670nm	SiO2, SiN, GaN, AlO2 GaAs InP	Effectively infinite ~ 2,000nm ~ 700nm
980nm	Most III-Vs Silicon	Effectively infinite ~ 2,000nm

- If in doubt…we simply model the performance.

Applications

Materials

III-V | Silicon | II-VI | Polymers | Dielectrics | Metals

Processes

RIE | ICP | Vapour Etch | ECR

Product Sectors

Optoelectronics
Lasers / Modulators / Detectors

Silicon Electronics
CMOS, trench isolation, wafer thinning, via holes

MEMS
Vapour release etch, deep silicon etch

III-V Electronics
HEMTs, HBTs

Photomask
Metal etch

Packaging
Topographic surfaces

Bio-Chips
Micro-channels

Failure Analysis

LEP500 Configurations

LEP500 Head / Mount

LEP500 PC-Based Controller

Wafer Vision System
(with advanced software features)

Manual or Motorised XY Stages

Digital I/O Communication Interface

Etch*Director* software

For;

- Modelling
- Simulation
- Data acquisition
- Integration with etch chamber
- Automated end pointing
- Data logging

All you need to supply is the etch chamber and a trolley and you will be getting results within 1 hour!

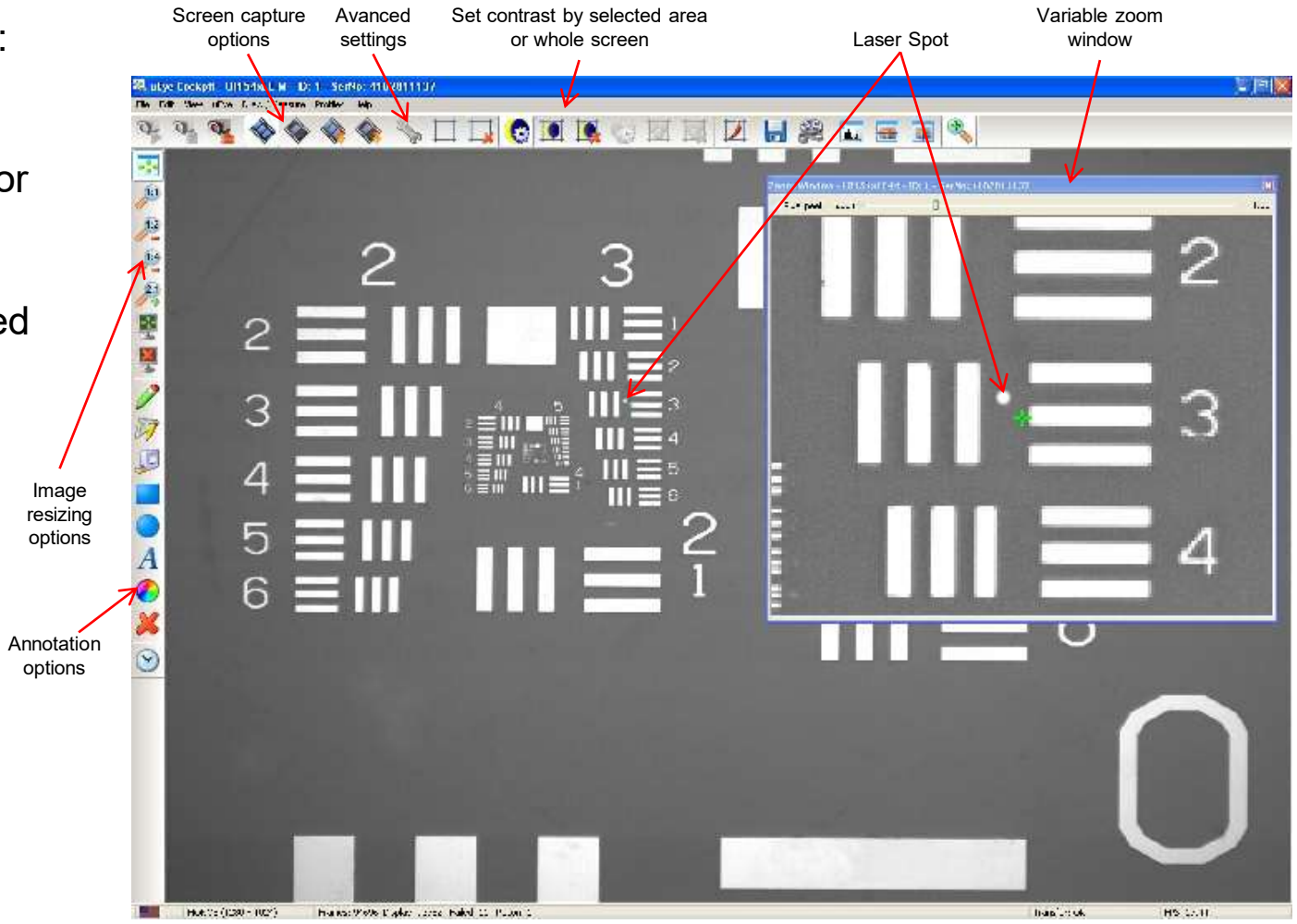
LEP500 Vision System

Standard Camera Resolution = 1280 x 1024 (higher resolutions available on request)

Laser Spot Size = 8μm to 25μm depending upon working distance

Image Viewing Features:

- Gain: Auto or manual lock
- Exposure time: Auto or manual lock
- Contrast: Auto, manual, over a defined area
- Edge Enhancement
- A range of zooming and resizing options

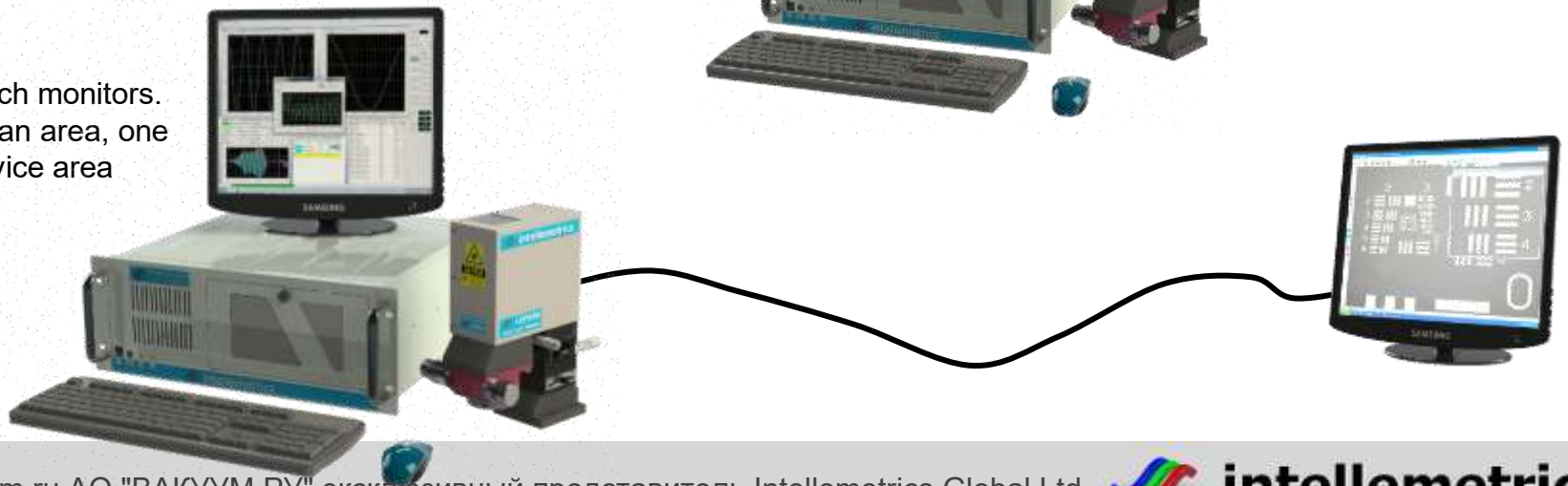


LEP500 Image Viewing Options

Two 22 inch monitors
side by side

One 27 inch monitor in
portrait mode

Two 22 inch monitors.
One in clean area, one
in service area

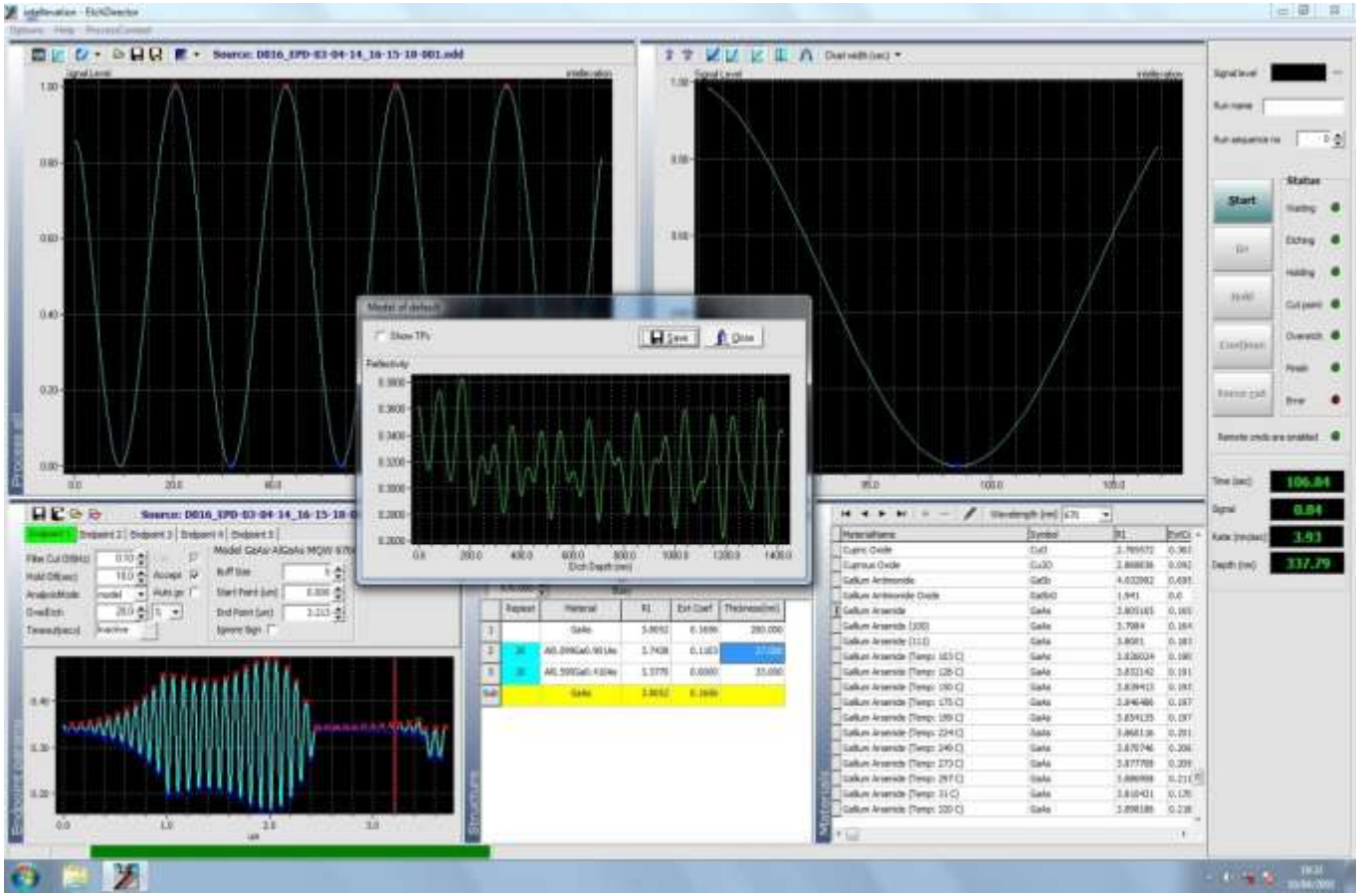


intellemetrics

Etch*Director* Software

Integrated software suite preinstalled with every Controller Module.

- Database of material properties (n and k data)
- Model reflectance vs etch depth of complex wafer stacks
- See live graphs of the signal vs time during the etch process.
- Setup an extensive range of end point conditions using a number of endpoint algorithms.
- Integrate the controller into the etch system for automated operation or use in a completely manual mode.
- Data logging of all run data.

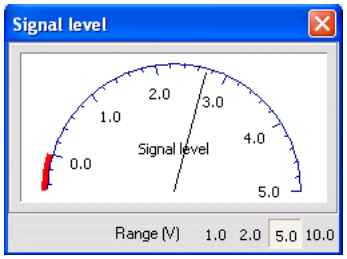


intellemetrics

Etch*Director* - Control Panel

Easy to use Master Control panel

Data Logging info



Signal Level Meter
for easy visual setup

Intuitive control buttons.
These enable the user to put the system into automatic control mode, or to manually take control of the etch process.

In MANUAL MODE the user presses these buttons to take full control.

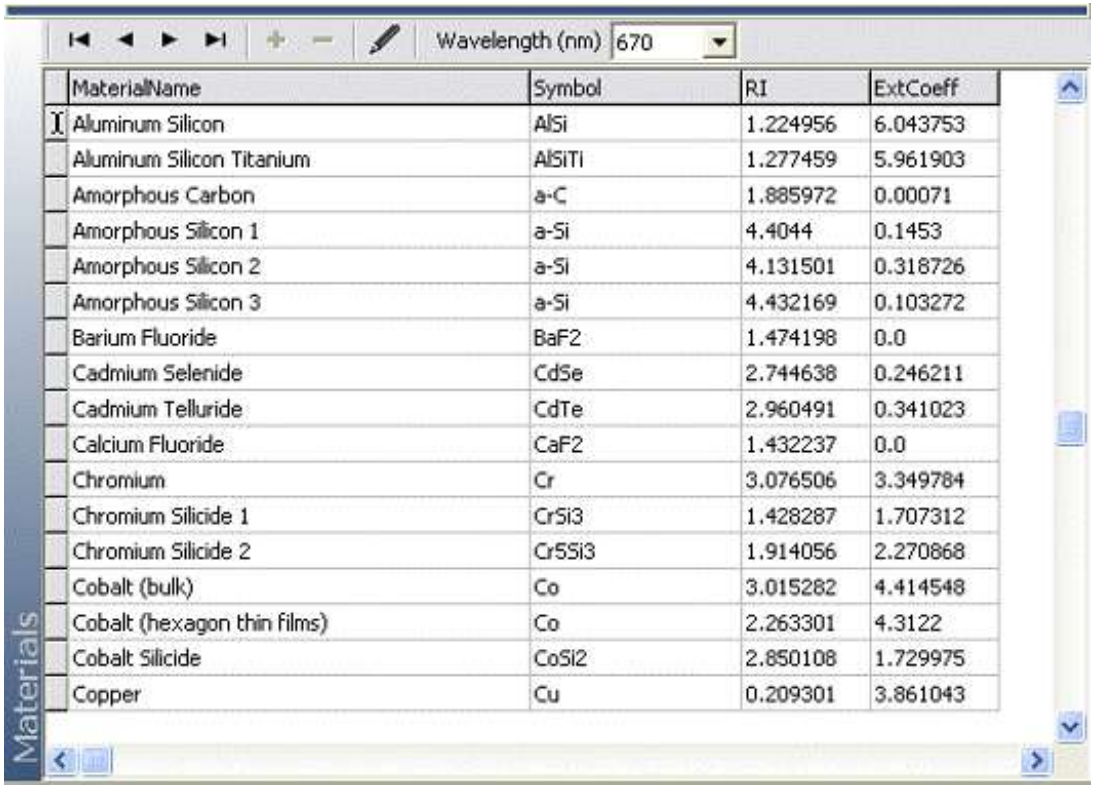
In AUTOMATIC MODE these buttons are controlled via digital IO from the plasma etch system.

Status LEDs

Process info
Etch time
Signal Level
Etch Rate
Etch Depth

Material Library

- > 250 Materials Supplied as standard for 670nm unit including n, k values
- User can add hundreds more custom layers
- Databases available at 670nm, 860nm, 980nm, 1500nm and 1550nm
- User can create databases at other wavelengths as required

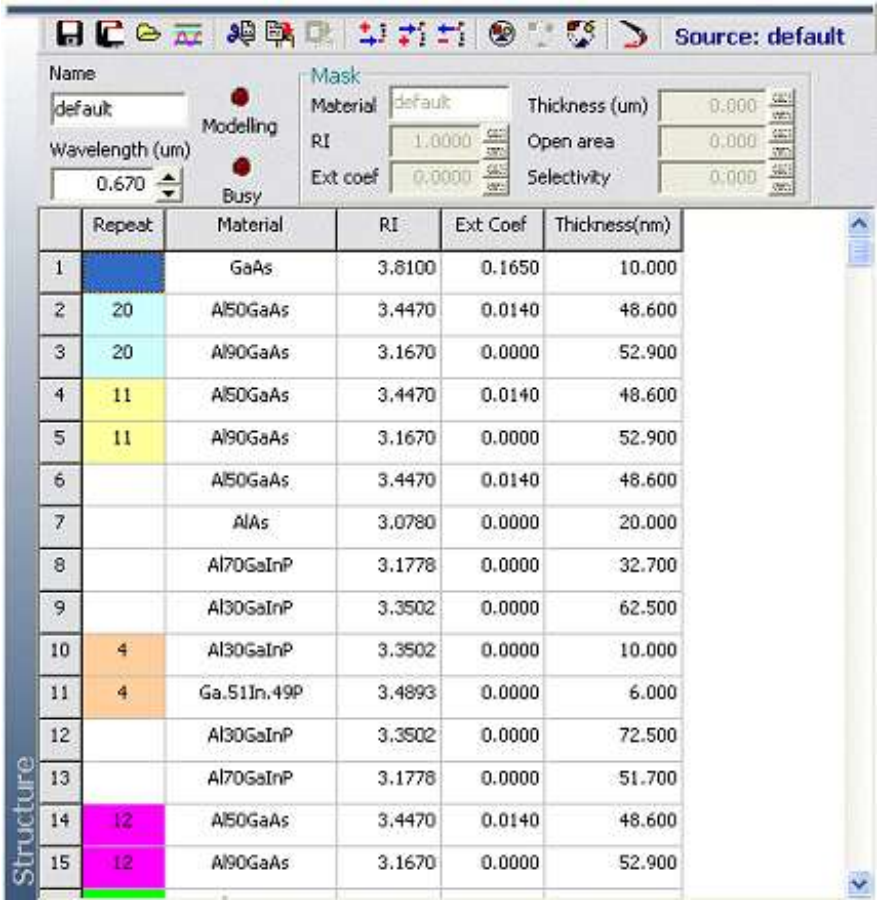


MaterialName	Symbol	RI	ExtCoeff
Aluminum Silicon	AlSi	1.224956	6.043753
Aluminum Silicon Titanium	AlSiTi	1.277459	5.961903
Amorphous Carbon	a-C	1.885972	0.00071
Amorphous Silicon 1	a-Si	4.4044	0.1453
Amorphous Silicon 2	a-Si	4.131501	0.318726
Amorphous Silicon 3	a-Si	4.432169	0.103272
Barium Fluoride	BaF2	1.474198	0.0
Cadmium Selenide	CdSe	2.744638	0.246211
Cadmium Telluride	CdTe	2.960491	0.341023
Calcium Fluoride	CaF2	1.432237	0.0
Chromium	Cr	3.076506	3.349784
Chromium Silicide 1	CrSi3	1.428287	1.707312
Chromium Silicide 2	Cr5Si3	1.914056	2.270868
Cobalt (bulk)	Co	3.015282	4.414548
Cobalt (hexagon thin films)	Co	2.263301	4.3122
Cobalt Silicide	CoSi2	2.850108	1.729975
Copper	Cu	0.209301	3.861043

Wafer Structure

User friendly system to enter the details of the wafer structure prior to modelling

- Load structure from file or create a simple or complex wafer structure
- Data input:
  - Input Materials directly from Material Database or custom user input
  - Layer thicknesses in μm, nm or Å
  - Rapid input for repeated quantum-well structures
  - Number of layers: 1 to many hundreds



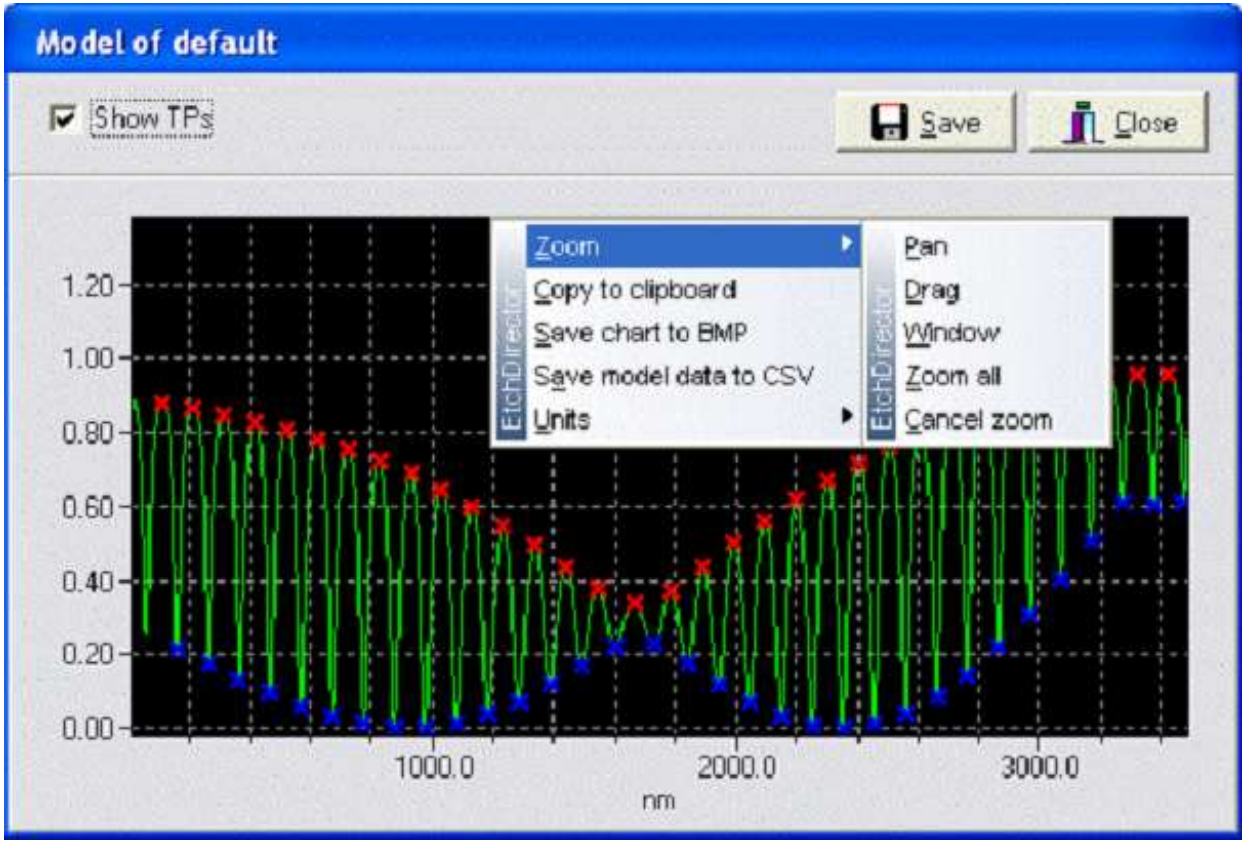
	Repeat	Material	RI	Ext Coef	Thickness(nm)
1		GaAs	3.8100	0.1650	10.000
2	20	Al50GaAs	3.4470	0.0140	48.600
3	20	Al90GaAs	3.1670	0.0000	52.900
4	11	Al50GaAs	3.4470	0.0140	48.600
5	11	Al90GaAs	3.1670	0.0000	52.900
6		Al50GaAs	3.4470	0.0140	48.600
7		AlAs	3.0780	0.0000	20.000
8		Al70GaInP	3.1778	0.0000	32.700
9		Al30GaInP	3.3502	0.0000	62.500
10	4	Al30GaInP	3.3502	0.0000	10.000
11	4	Ga.51In.49P	3.4893	0.0000	6.000
12		Al30GaInP	3.3502	0.0000	72.500
13		Al70GaInP	3.1778	0.0000	51.700
14	12	Al50GaAs	3.4470	0.0140	48.600
15	12	Al90GaAs	3.1670	0.0000	52.900

Model Output

Models reflectance as a function of etch depth for a wafer stack created using Structure*Maker*.

Graphical Visualisation

- Signal vs Etch Depth
  - in μm, nm or Å
- Turning point markers
  - On / Off
- Zoom Modes
  - Pan
  - Drag
  - Window
  - Zoom All
- Save Modes
  - .mod
  - BMP
  - CSV

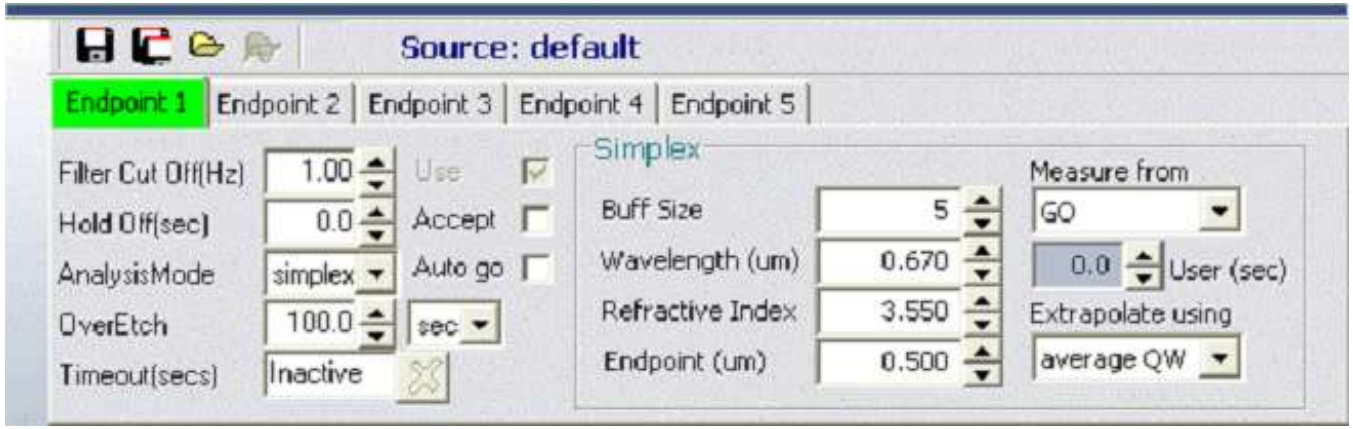


End Point Detection

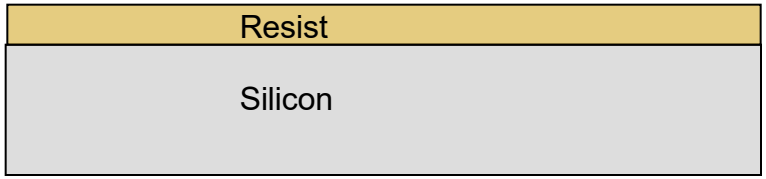
- **Etch*Director*** detects a wide range of endpoint conditions.
- Once the condition is reached **Etch*Director*** can direct I/O to the etch tool to automatically terminate the etch…..ideal for production environments
- Different endpoint detection algorithms are supplied to suit a wide range of applications
- Number of Programmable Independent Sequencial End Points: 5
- Common Independent End Point Parameters
  - Filter Cut Off (Hz)
  - Hold Off (sec)
  - Over Etch: Time or %
  - Timeout (sec): Active / Inactive
  - Measure End Point from: Go / Hold Off / User Defined Time

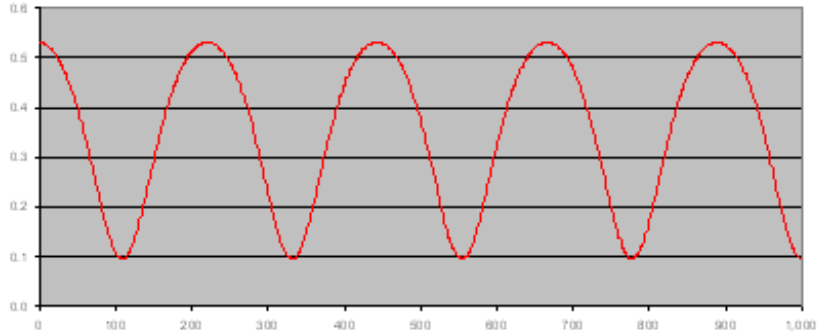
End Point Detection: Simplex Mode

- Targets a specified depth based on an entered refractive index and wavelength
- Ideal for rapid monitoring of simple structures



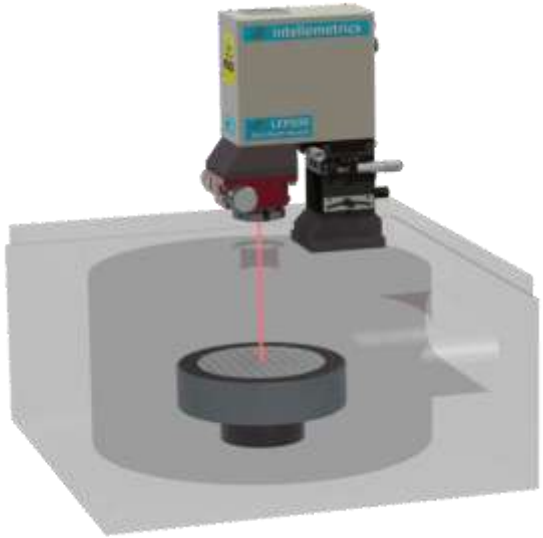
e.g. clearing resist off Si

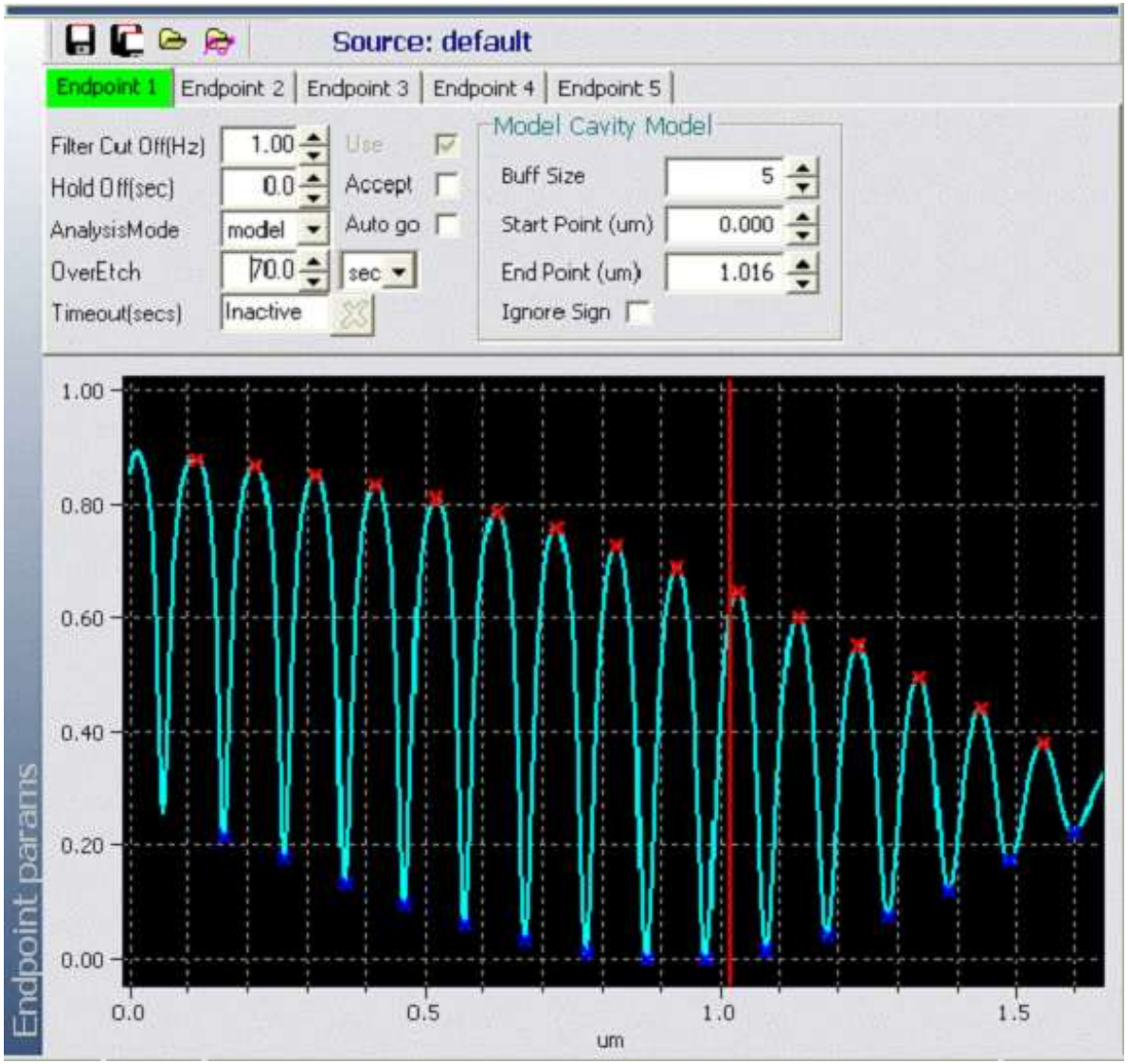




End Point Detection: Model Mode

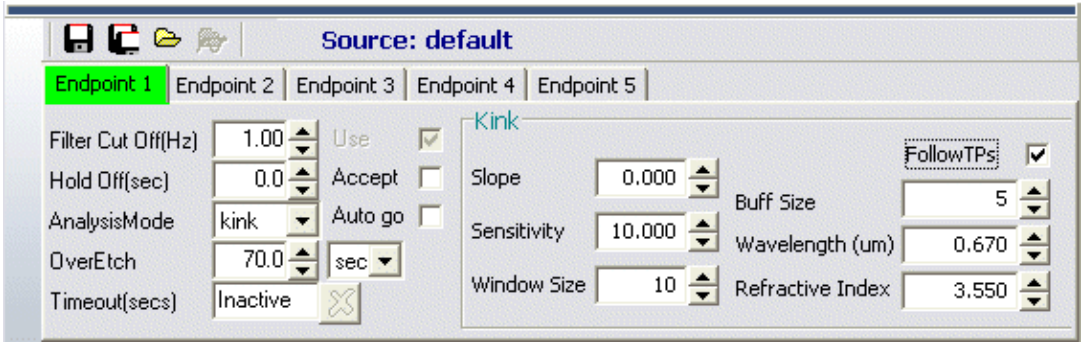
- Targets a specified depth based on the anticipated turning point sequence of a modelled wafer structure.
- Ideal for all situations including complex wafer structures.



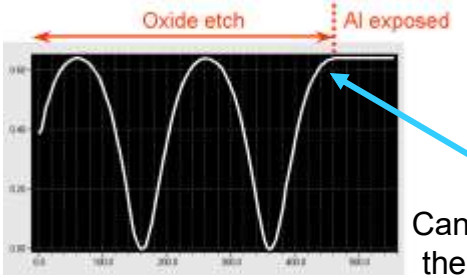


End Point Detection: Kink Mode

- Targets a change in the reflectance trace



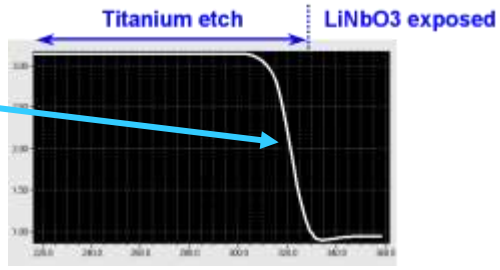
Works in two distinct modes:



Hunts for a 'flatline'.
Can be set to endpoint anywhere on the 'cusp' or into the flatline region.

Ideal for endpointing on an etch stop.

Hunts for a threshold in slope.
Can be set to endpoint anywhere down the slope.



Ideal for endpointing during metal etch or other absorbing structures.

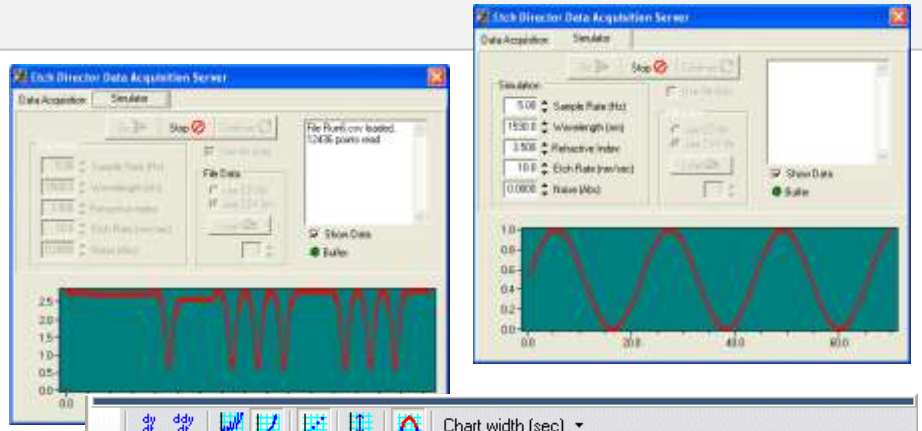
Does not require layer thickness to be known!
Proven to detect the interface well before a skilled human operator!

Simulator

Reads in saved RAW data in Real Time to simulate an etch run

Data from:

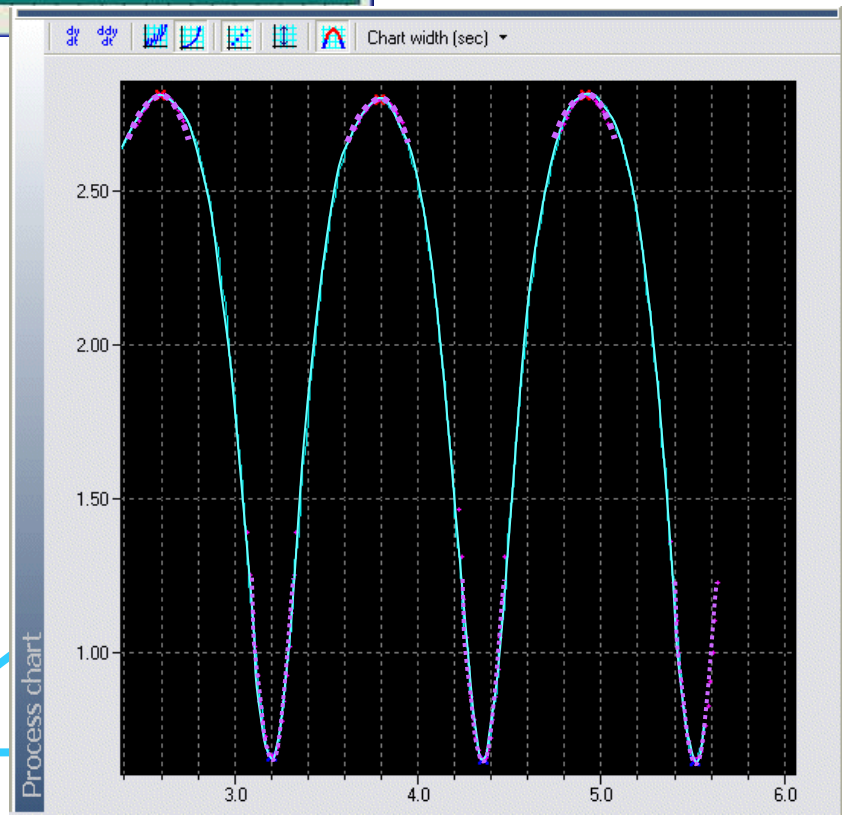
- A previous run
- Standard sine wave
  (plus programmable noise)



Enables runs to be simulated OFFLINE with different endpoint analysis modes, filter settings, hold-off, over-etch, etc

Test your process will hit the required endpoint every time

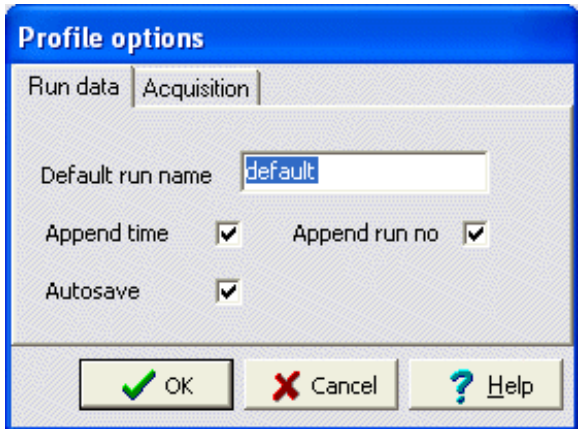
Ideal for rapid process optimisation on a desktop computer



Simulated run showing:
Filtered data
Turning point fitting

Data Logging

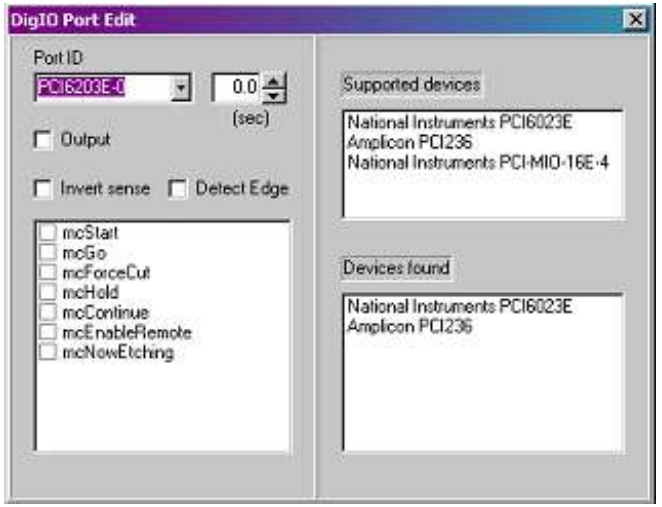
- Automatic Data Logging of each run
  - Raw data
  - Filter settings
  - Endpoint parameters
- User Specified
  - Directories
  - Filename Formats
- Includes
  - run number
  - sequence number
  - date and time stamping



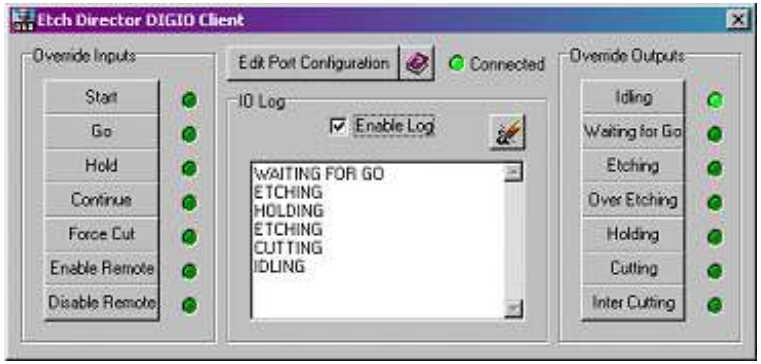
- Automatic data logging of all Control Panel status changes

Interface Options

- Digital I/O provided as standard for integration of LEP400 into a customer's etch tool
- 8 TTL I/O Lines on a 25 way socket
- Fully configurable via DIGIO Client software within **Etch*Director***
- Further I/O available on request
- Automatic search and recognition of a range of digital IO PCI cards
- Mutliple cards of the same or mixed type can be used
- Automatic search and recognition of the appropriate drivers
- Establishes the following virtual status outputs
  - Idling / WaitingForGo / Etching / OverEtching / InterCutting / Cutting / Holding
- Establishes the following input command inputs
  - Start / Go / ForceCut / Hold / Continue



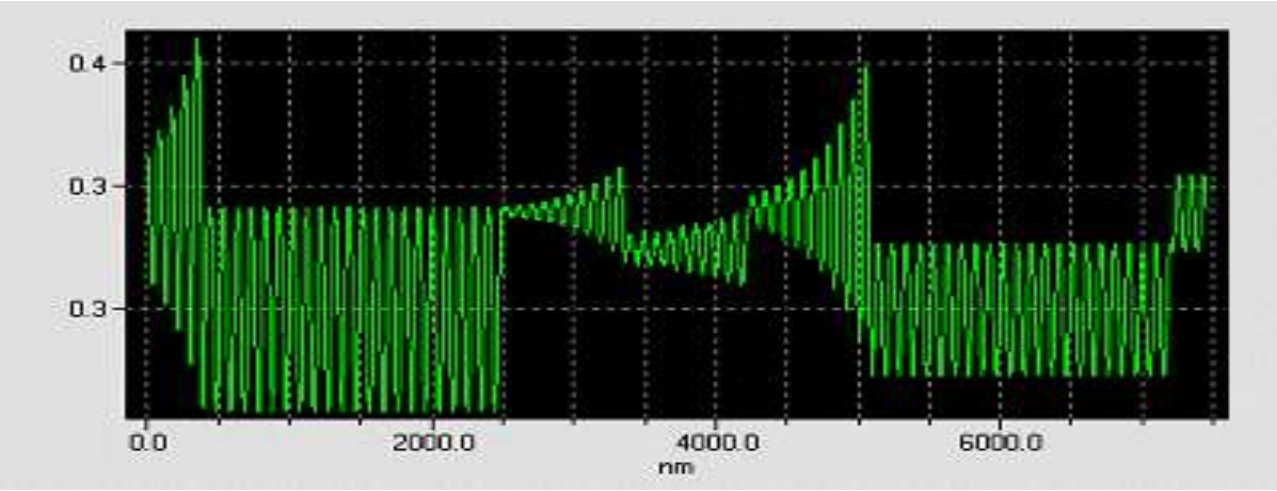
- Any physical digital input on any card can be mapped to any virtual input or any number of virtual inputs.
- Any physical digital output on any card can be mapped to any virtual output or number of outputs
- Runs as a free standing executable with its own GUI which simplifies setting up of the digital IO
- Provides push buttons to override inputs and outputs
- Provides LEDs to show status of inputs and outputs
- Provides a log to record in/out activity
- The physical characteristics of the ports can be edited on a port by port basis.
  - direction …input or output (if supported by card)
  - sense… inverted or normal
  - edge or level triggered if an input
  - pulse or fixed if an output
  - qualification period presetable for inputs
  - pulse period presetable for outputs



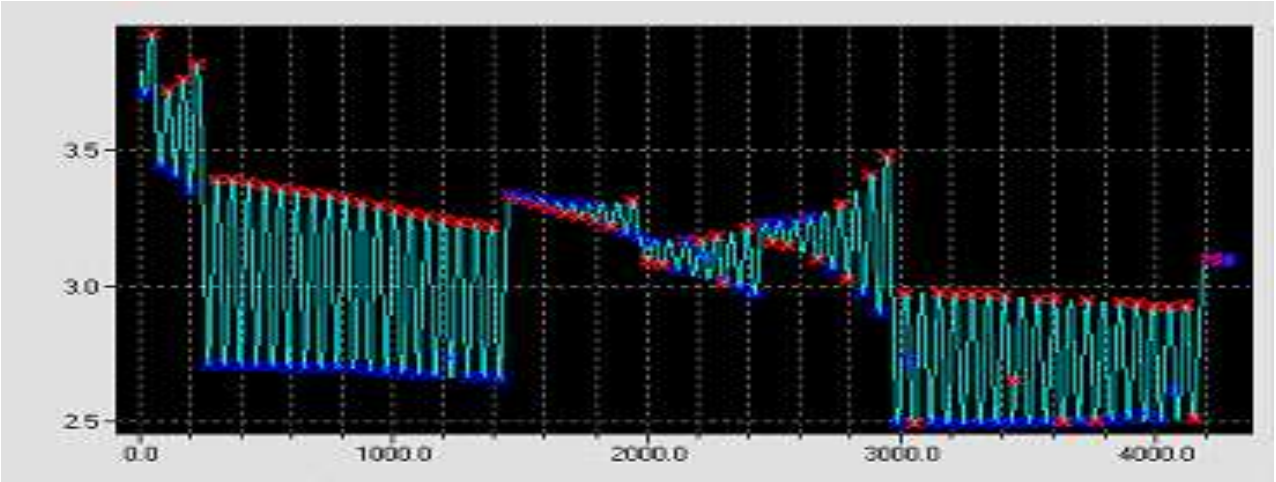
Example - Optoelectronics

GaAs/AlGaAs Quantum Cascade Laser Etch

Courtesy of Dr Geoff Hill, Sheffield University, UK

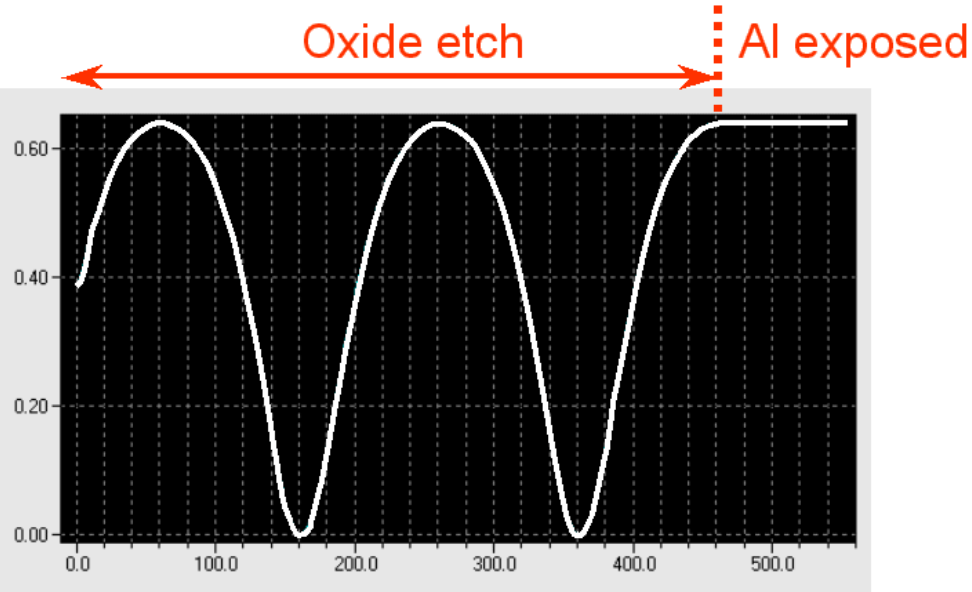


Etch*Director* model



Actual run data

Example – Failure Analysis

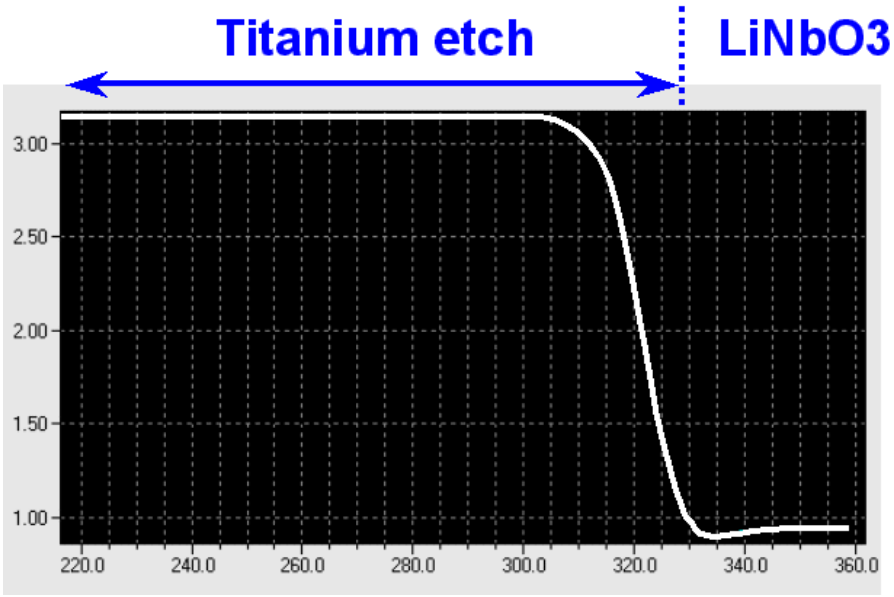


Etch*Director* detects the 'flat-line' at the end of the oxide etch avoiding unwanted removal, damage or contamination of the underlying Al layer.

A major advantage of this algorithm is that reliable endpointing does not depend upon the starting oxide thickness. This is especially important in a manufacturing environment where premeasurement of the oxide thickness is prohibitive in terms of time and cost.

Ideal for monitoring the etch of SiN on metal or even combinations of SiN on SiO2 or on Si.

Example – Metal Etching



Metals are not transparent until very thin and therefore you cannot obtain interference fringes and monitor etch depth & rate through the bulk of a metal layer.

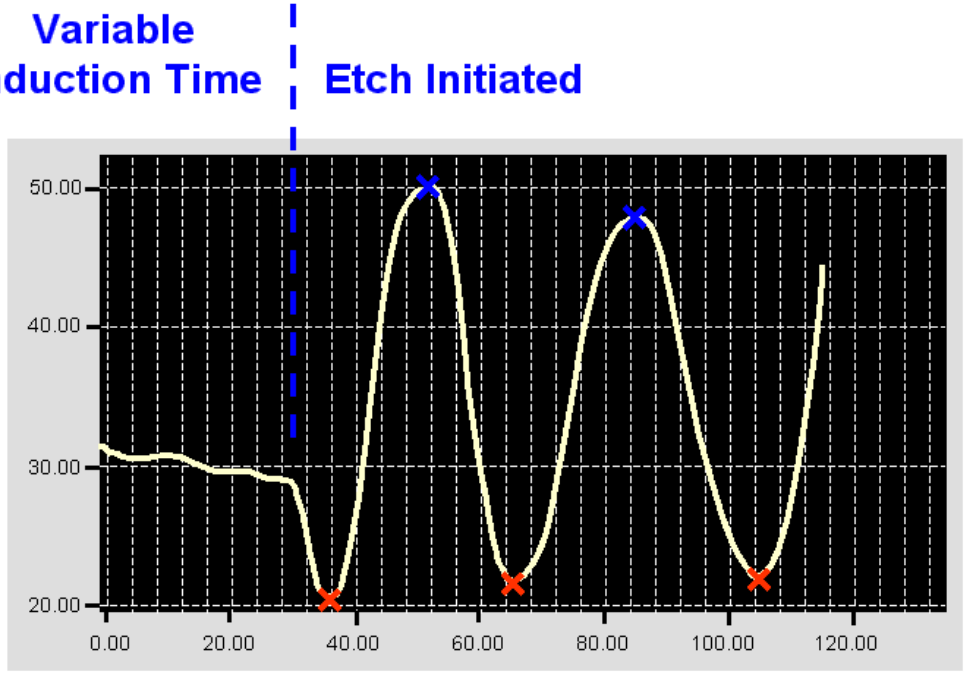
However, the LEP500 is ideal for picking out interfaces, indicated by a step level change in reflectivity.

Etch*Director* comes with an endpoint algorithm specifically designed to identify this step level change and enables the operator to choose whether to stop at the top, middle or bottom of the curve. Again, an overetch capability is also included to enable a clearout etch to be achieved.

A major advantage of this algorithm is that reliable endpointing does not depend upon the starting metal thickness. This is especially important in a manufacturing environment where premeasurement of the metal thickness is prohibitive in terms of time and cost.

This process works even at high etch rates and has been proven to be faster and more accurate than a skilled operator. The process works equally well for other metals including NiCr, Ni, Au, Tg, Pt, etc, and works for a wide range of substrates.

Example – Selective Low Damage Etch



Selective low damage plasma etch processes are used in a number of applications including III-V etching of InP & GaAs HEMTs and for active III-V optoelectronic devices including lasers, modulators and detectors.

Often these processes experience an induction period at the beginning of the etch process during which the native oxide, and/or residues from the previous process stage, inhibit the etch. Once this layer has been removed the etch proceeds as normal.

The problem is that the induction time is variable and may become a significant proportion of the expected etch duration. Without in-situ monitoring this can lead to large uncertainties in the etch depth.

The LEP500 enables the operator to actually 'see' the induction period, as shown in the graph above, and still obtain a highly accurate and repeatable etch process.

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