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P12 P15 P17 P9 R7 S12 S4 T14 T21 T26 T3
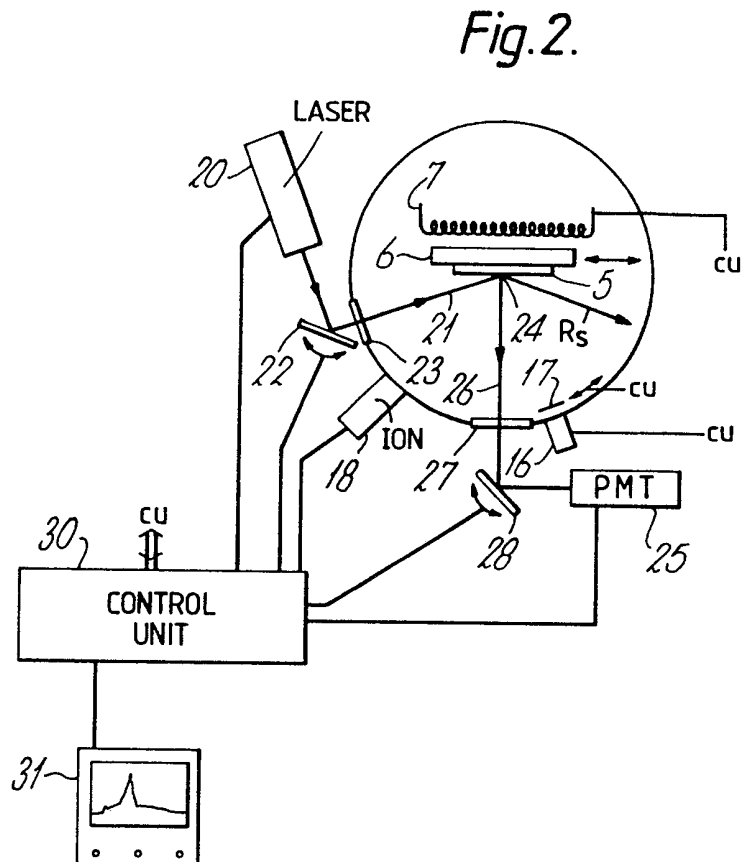**U1S** 1421 1489 1592 1664 1914 2121 2182 G1A

(56) Documents cited
GB 1488049   GB 0731865   US 3892490

(58) Field of search
G1A
Selected US specifications from IPC sub-classes G01B
G01N

(54) **Monitoring substrate surfaces and surface layers**

(57) The surface of a substrate 5 is monitored during cleaning and subsequent layer growth by illuminating a small area of a surface of the substrate and detecting light scattered in a non-specular direction 26. The amount of light scattered varies strongly with surface characteristics and gives clear indication of the end of oxide removal, initiation of nucleation and quality of growing layers. The monitoring is used during e.g. chemical vapour deposition, or e.g. molecular beam epitaxy growth processes, to control the process parameters.

The light beam is scanned across the surface by mirrors 22,28 and may be polarised and continuous or pulsed. The specularly reflected beam Rs may be used as a reference.
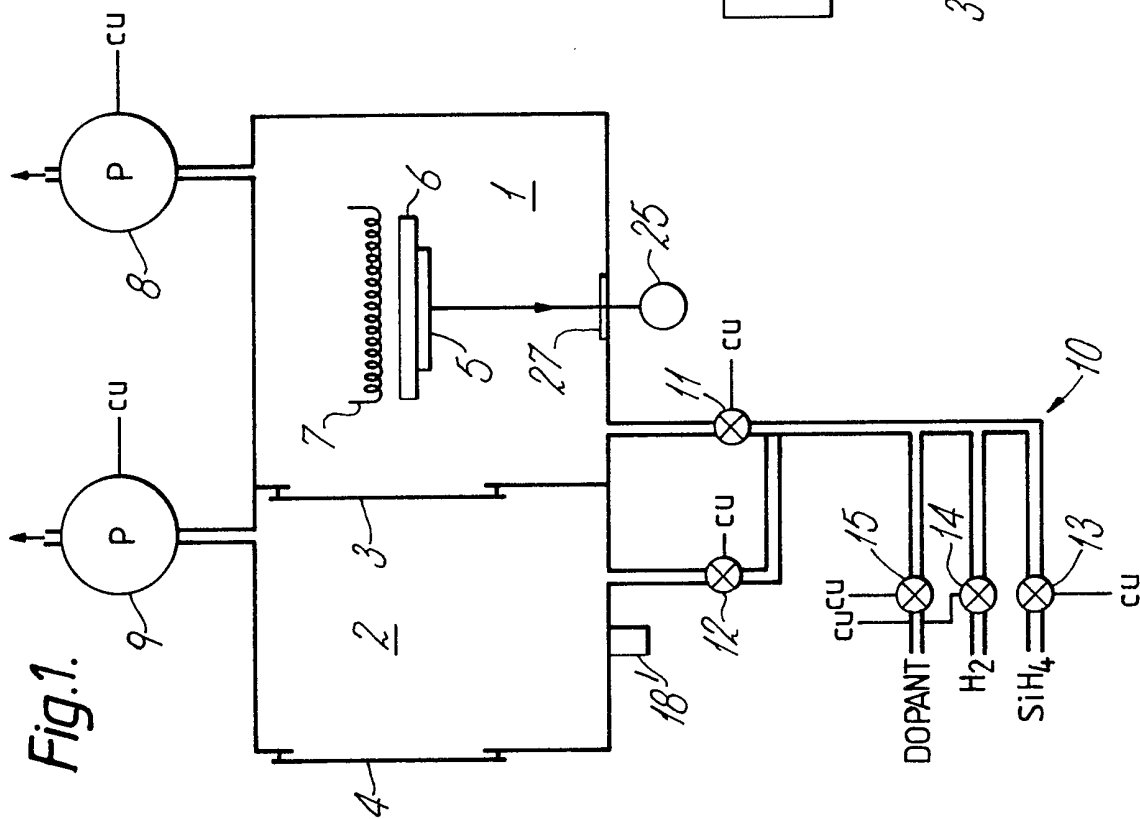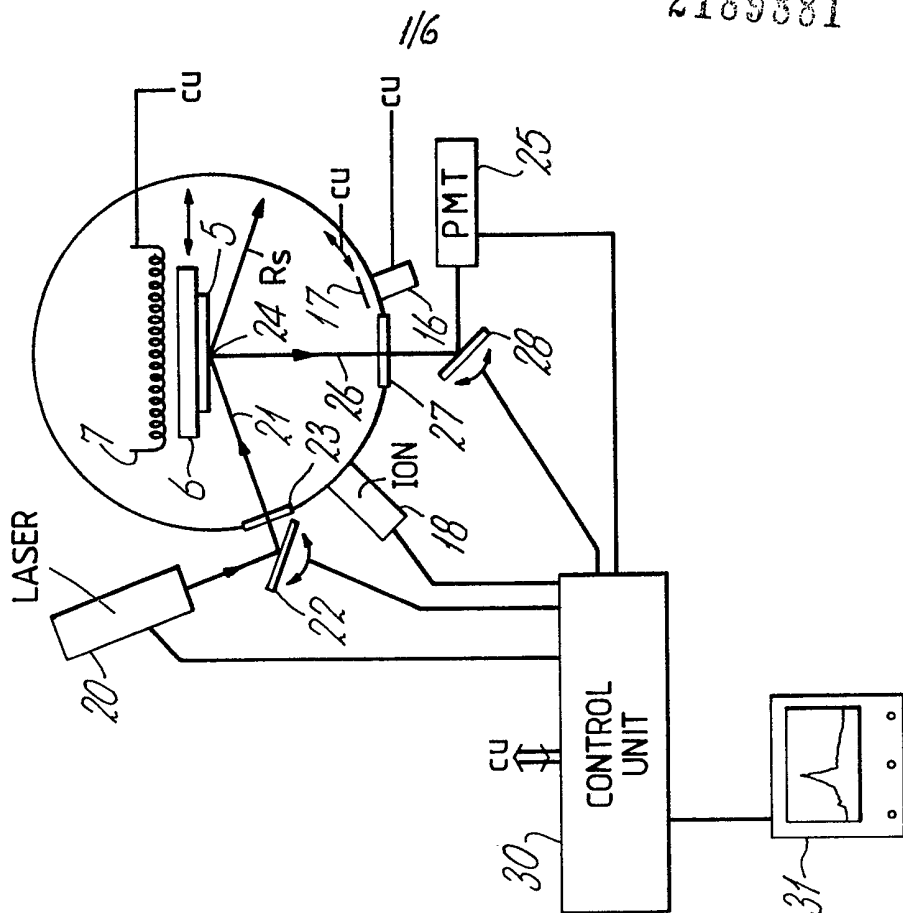
Fig.2.

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Fig.2.

LASER

20

22

21

23 26

24 Rs

17

16

28

27

ION

18

PMT

25

7

6

5

cu

cu

cu

CONTROL
UNIT

30

31

cu

Fig.1.

P

8

P

9

cu

cu

7

6

5

1

2

3

4

27
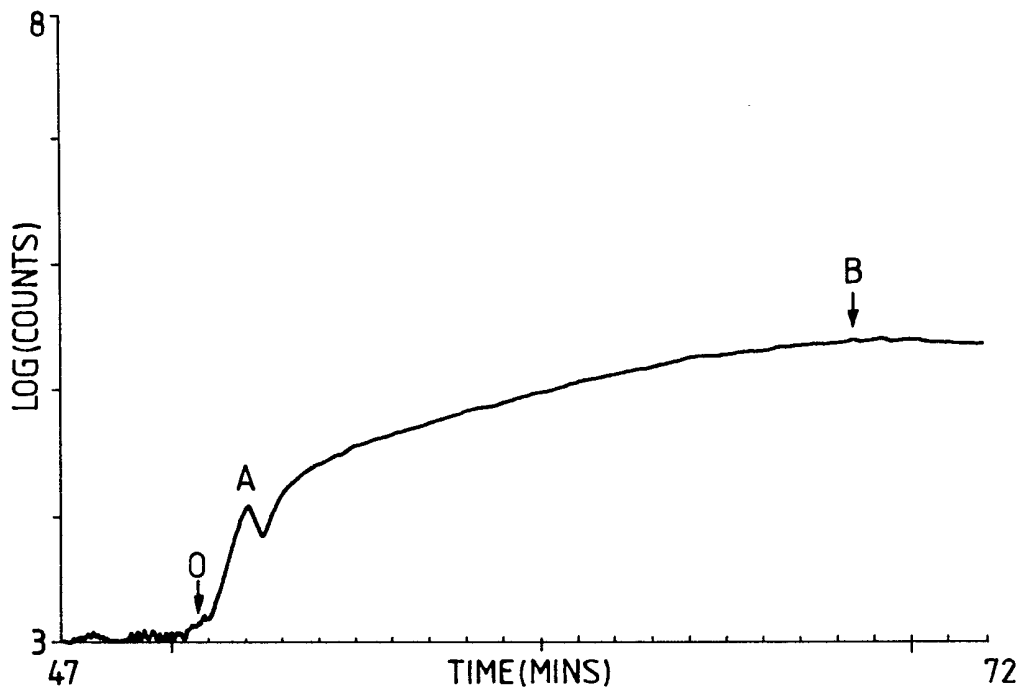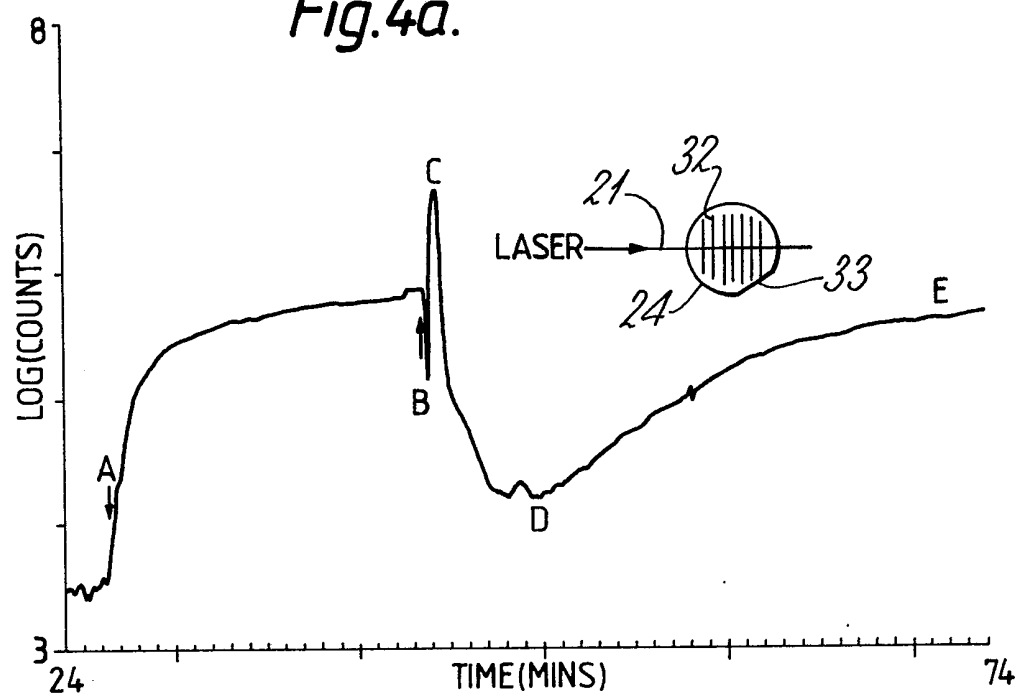
25

18

11

12

cu

cu

cu

10

15

14

13

DOPANT

H₂

SiH₄

cu cu

cu

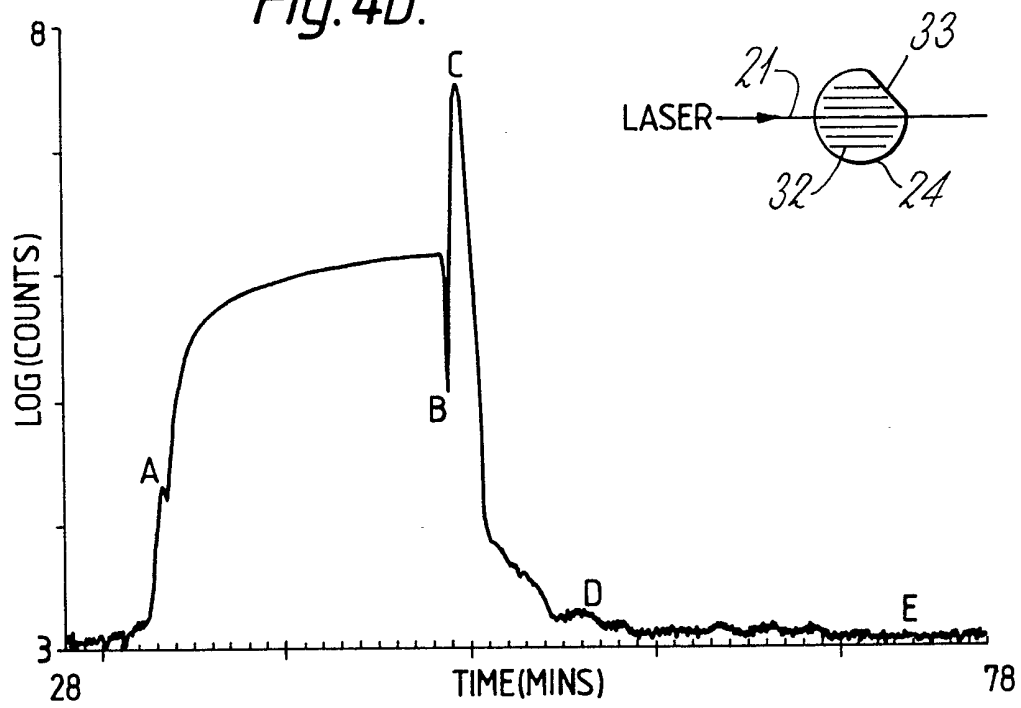# Fig.3.

Fig.4a.

Fig.4b.

Fig.5a.

Fig.5b.

Fig.5c.

ESTIMATED POSITION OF
CRITICAL BOUNDARY
(From a whole series of growth runs)

DEFECTIVE
MATERIAL

GOOD QUALITY
EPITAXY

Fig.5b.

Fig.5a.

GROWTH RATE (μm MIN^{-1})

0.5
0.4
0.3
0.2
0.1
0

750   800   850   900

T (°C)

Fig.6.

LOG (COUNTS)

8

C

A

B

O

3
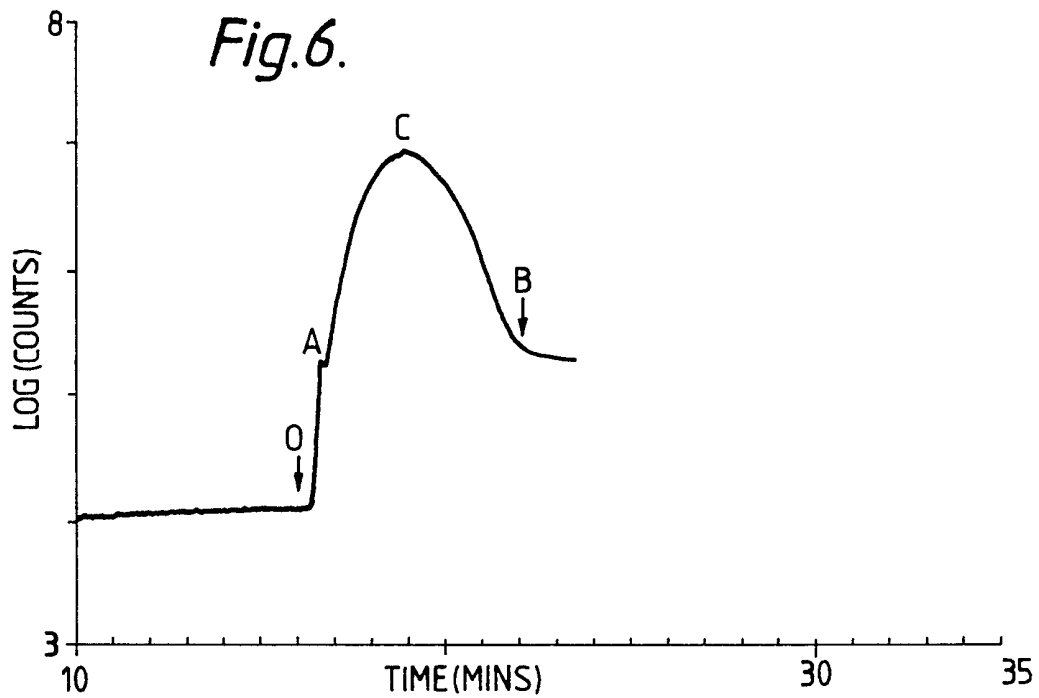
10   TIME (MINS)   30   35
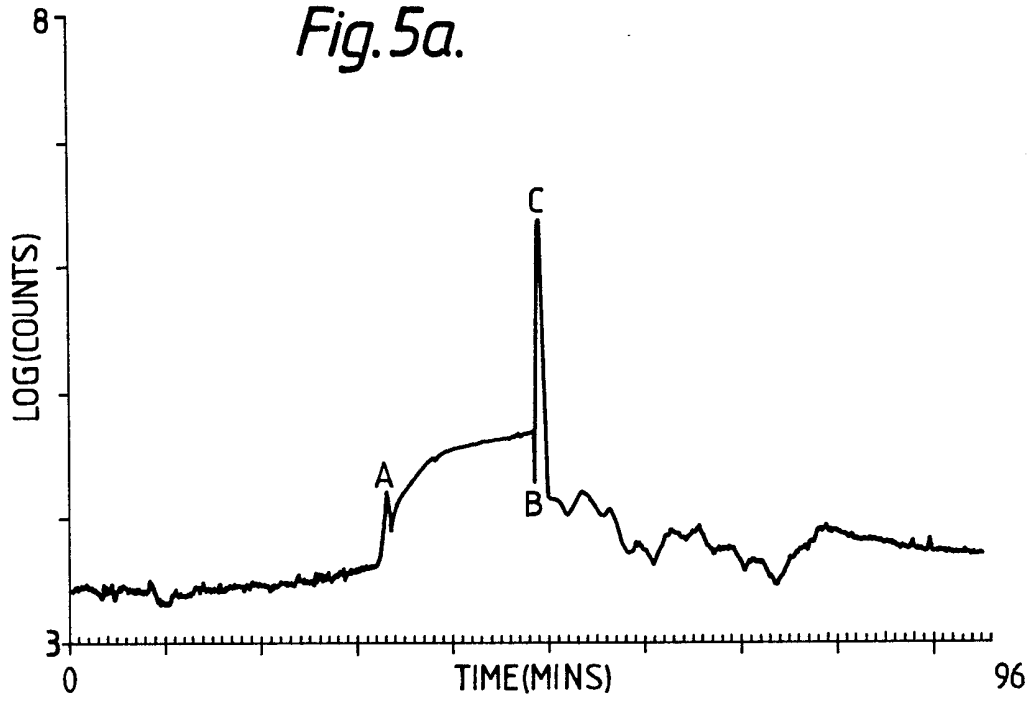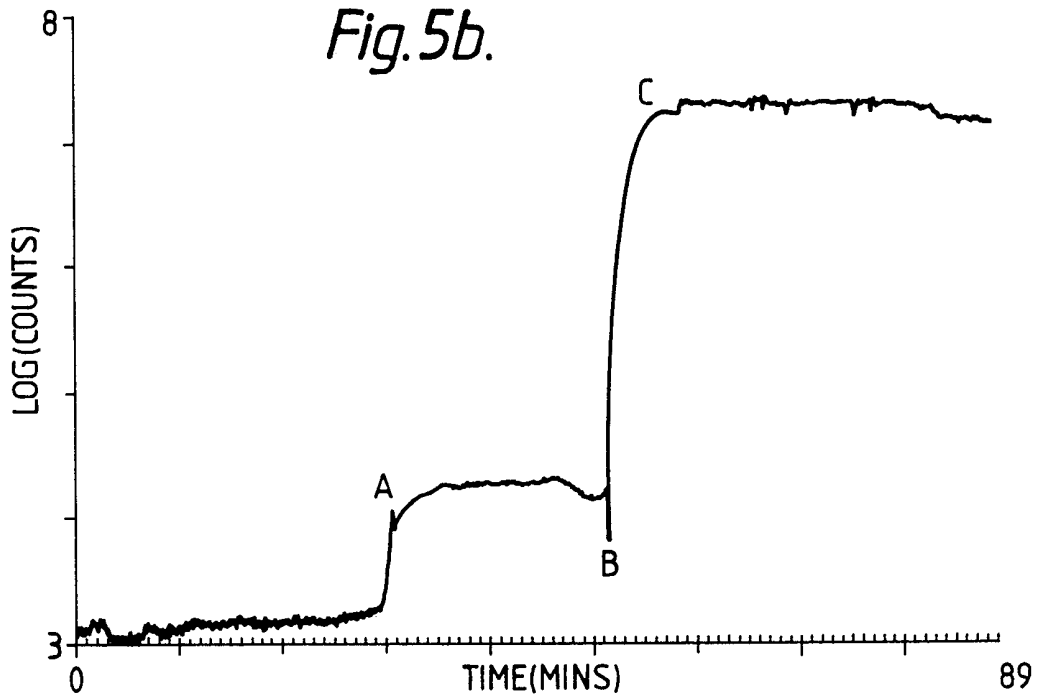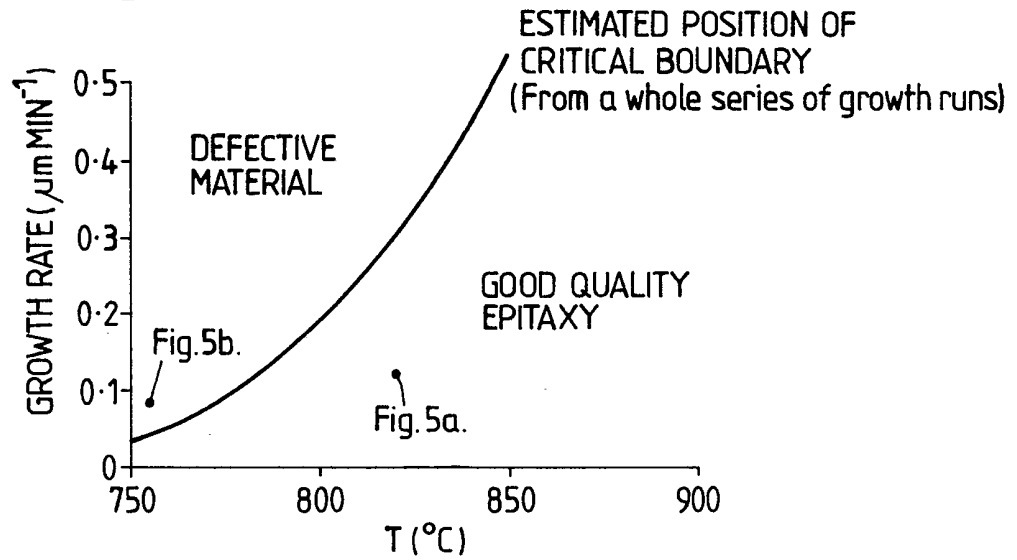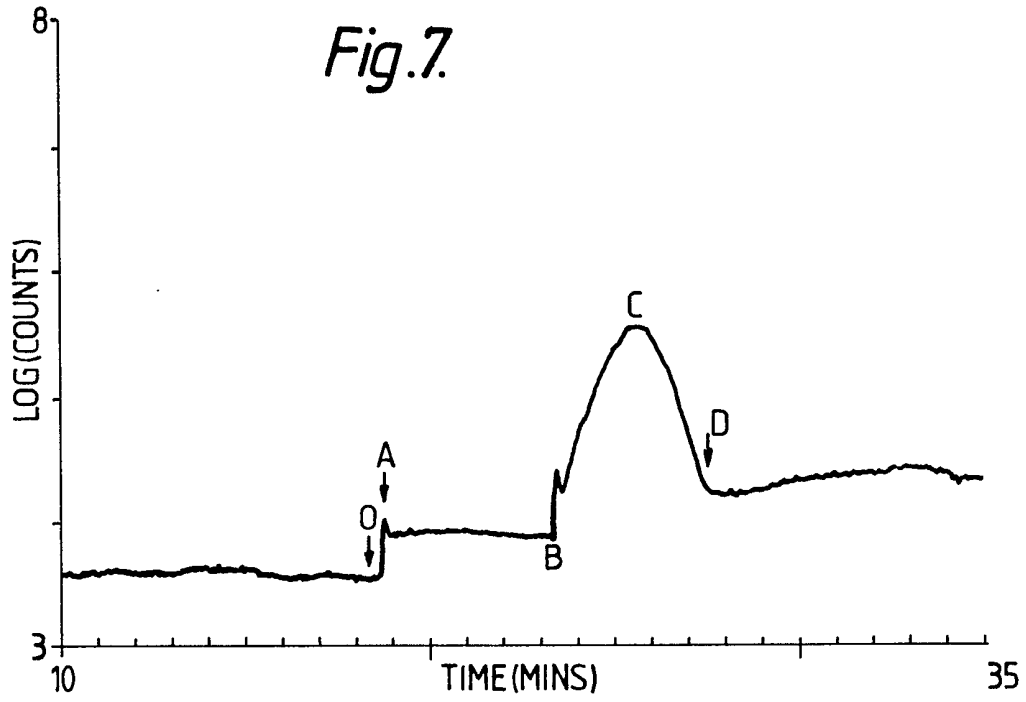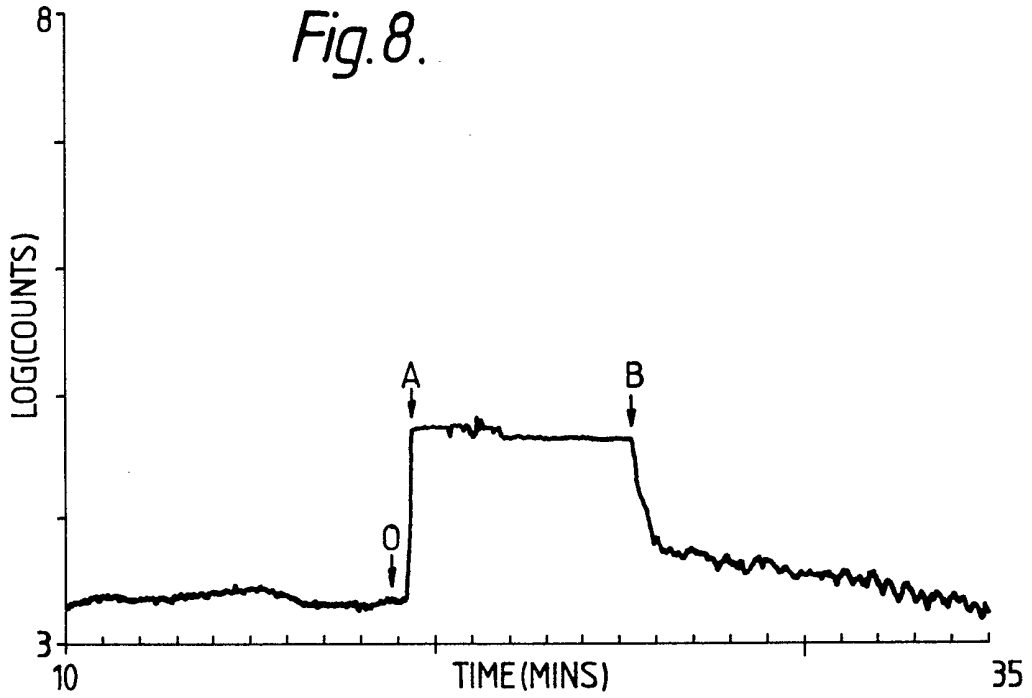
Fig.7.

Fig.8.

SPECIFICATION

Method and apparatus for monitoring surface layer growth

5   This invention relates to a method and apparatus for monitoring changes in surfaces and surface   5
layers.
    Many device manufacturing processes involve cleaning, preparation and depositing thin layers
on a substrate. The degree of perfection of a thin film on a substrate is important in many and
diverse applications. Examples are semiconductor layers, epitaxial, polycrystalline or amorphous,
10 insulating layers, thin film coatings on optical components and on optical or magnetic memory   10
devices, etching of surfaces, and preparation of non-specular surfaces e.g. solar converters.
    Some of the factors determining the quality of a thin film are the perfection and the cleanliness
of the substrate surface. The same is true for deposition of subsequent films. It is not easy to
clean say a layer of silicon oxide off a silicon substrate without either incompletely cleaning the
15 surface or removing material from the substrate surface. Both may degrade the interface be-   15
tween substrate and grown layers.
    Various systems are now in use for growing layers. For example chemical vapour deposition
(CVD), and molecular beam epitaxy (MBE). These processes are carried out in closed chambers
that can be thoroughly cleaned. There remains the problem of knowing what is happening at the
20 surface of a substrate in the closed chamber.   20
    Use of scattered light to monitor growing interfaces is known from O. N. Mesquita et al,
Physical Review B, Vol. 29 No. 5, 1 March 1984, pages 2846–2849; and H. Durig et al,
Physical Review A, Vol. 30 No. 2, August 1984, pages 946–959. These describe directing light
through a crystal to the crystal-liquid interface in a zone refining cylinder. Reflected light provides
25 information about crystalline growth at the interface.   25
    Such prior art provides no information on the cleaning and subsequent growth of epitaxial
layers on a flat slice of semi-conductor material.
    Surface statistics, roughness, etc., can be calculated from scattered light. This is described in
Optical Engineering, July/August 1984, Vol. 23 No. 4, J. C. Stover et al, pages 406–412;
30 Applied Optics, 15 October 1984, Vol. 23 No. 20, P. Roche & E. Pelletier, pages 3561–3566;   30
S.P.I.E. Vol. 511, Stray Radiation IV 1984, R. M. Silva et al, Pages 38–43.
    Specularly reflected light has been used in the growth of coating layers. See for example U.S.
Patent No. 3,892,490, G.B. Patent No. 731,865, European Patent No. A.2, 0,150,945.
    The above problem is solved according to this invention by directing a beam of light onto the
35 surface of a substrate and detecting light scattered off the substrate in a non specular reflection   35
direction. Changes in the intensity of detected light are then used to change process parameters,
eg change from a cleaning step to a layer growth step.
    According to this invention a method of monitoring surface conditions on a surface of a
substrate being processed includes the steps of:–
40   directing a beam of light onto at least one small area of the surface being monitored;   40
    detecting light scattered from said small area in at least one non-specular reflection direction;
    changing the process parameters in response to detected changes on the surface.
    The processing of the surface may be a cleaning, a removal of oxide or other compound, a
deposition of layers of materials the same or different from the original, substrate, surface.
45 These layers may be deposited by chemical vapour deposition (CVD), metal organic chemical   45
vapour deposition (MOCVD), molecular beam epitaxy (MBE), etc.
    The change in process parameters may be a change from a cleaning step to a growth of
layers, or a change from growing layers of different materials or cessation of growth at a
specified end point.
50 Preferably the processing is carried out in a vessel capable of withstanding high or very low   50
pressures. This enables the vessel and contents to be thoroughly cleaned prior to and during
processing.
    According to this invention apparatus for monitoring surface conditions of a substrate in-
cludes:–
55   a closed vessel capable of holding a substrate to be processed,   55
    means for cleaning or otherwise preparing a surface of the substrate,
    means for depositing a layer of material on the cleaned surface,
    characterised by:–
    means for directing light onto at least one small area of the surface less than the total area of
60 the surface,   60
    means for detecting light scattered from the small area in at least one non-specular reflection
direction,
    means for changing the cleaning or layer growth parameters in response to detected changes
of scattered light.
65   Preferably the vessel is a pressure vessel and or a vacumn tight vessel and contains different   65

sections with air locks to allow loading and discharging of contents without contaminating of the
cleaning and growth section.
      An argon ion laser emitting at 488nm may be used for the light source. The light source may
be operated continuously, or pulsed ON and OFF. Alternatively white light or other non-laser light
5   sources may be used. The light may be plane polarised and its polarisation axis may be rotated   5
relative to the surface being monitored. Measurements at different angles of polarisation are then
made. The detector may be a photon counting photomultiplier tube with a 488nm bandpass
filter.
      The amount of light scattered in a non-specular direction has been found to be unexpectedly
10 high. It is very sensitive to surface changes on a nanometre scale that occur e.g. during cleaning   10
and deposition of silicon. In some cases the surface features generated by cleaning or deposition
are directional and or periodic. In this case the intensity of scattered light varies strongly with
angle of incidence and direction of detection. More detailed information on topography can
therefore be obtained from measurements in more than one direction. Also the intensity of
15 scattering in a given direction is wavelength dependent. Further information is obtained from   15
measurements at different wavelengths.
      Non-specular light may be detected both on reflection from a surface or just below the
surface, and after transmission through a substrate. The light may be scanned over the surface
of one or more substrates to form a map of the or each substrate.
20 Principal uses of the above method are   20
      1. To display in real time changes in surface topography during preparation and cleaning of
substrate, and during layer deposition.
      2. To control changes in process parameters in response to measured surface changes, in
order to optimise cleaning or growth conditions.
25   3. To monitor effects of changes in process parameters, to ensure they comply with specified   25
limits.
      4. To indicate specified end point during deposition (or etching) sequence.
      5. To 'map' substrate surface if scanning optics or a moving substrate system is used, to
monitor uniformity in processing.
30   6. To indicate a particular growth mode e.g. step arrays, solid phase epitaxy, surface segrega-   30
tion.
      7. To indicate the existance of defects in a growing layer.
      The invention will now be described, by way of example only, with reference to the accom-
panying drawings of which:–
35 Figures 1, 2 are schematic side and end views of a pressure or vacumn chamber for growing   35
thin layers on a substrate;
      Figure 3 is a graph showing scattered light against time of a silicon substrate being cleaned of
an oxide layer;
      Figures 4(a), (b) are graphs showing growth of a silicon layer using light measurements from
40 two different directions;   40
      Figures 5(a), (b) respectively show growth of a good and a poor quality layer of silicon;
      Figure 5(c) shows the approximate boundary between good quality and poor quality crystaline
material for different growth rates with temperatures;
      Figures 6, 7, 8 are graphs showing growth of silicon layers using MBE techniques.
45 The apparatus shown somewhat schematically in Figs. 1, 2 is for cleaning substrates and   45
growing layers thereon. The apparatus comprises a main growth chamber 1 capable of with-
standing a high pressure or a very low pressure. Fixed to the growth chamber 1 is a loading
chamber 2 which comunicates with the inside of the growth chamber 1 through an entry lock 3.
An entry lock 4 on the loading chamber 2 allows loading of substrates 5. Inside the growth
50 chamber 1 is a substrate holder 6 capable of movement to move a substrate between cham-   50
bers. A heater 7 is arranged to heat the substrate 5 to the required temperature. Pumps 8, 9
evacuate the chambers 1, 2 as required. An inlet manifold 10 supplies various gases to the
growth chamber 1 through a valve 11 and to the loading chamber 2 through a valve 12. As
shown the manifold 10 receives three gas supplies of e.g. silane, hydrogen, and dopant, through
55 valves 13, 14, 15. Knudson ovens 16 (one only shown) supply their contents onto the substrate   55
5 as allowed by associated shutters 17. An ion gun 18 is arranged to irradiate the substrate 5
as needed.
      An argon ion laser 20 emitting about 10mW at 488nm is mounted to direct its light output
21 via scanning optics 22 and a window 23 onto a small area 24 on the substrate 5. Laser
60 light 21 will reflect in a specular manner as indicated by line Rs but this specular reflection is not 60
used. Instead a detector 25 is mounted above the substrate 5 to receive light 26 via a window
27 scattered in the plane of the laser light 21 in a non-specular direction. Other angles and
planes may be chosen instead of or in addition to that shown. The detector 25 may be a
photon counting photomultiplier tube with an 488 nm bandpass filter, suitable collecting lens and
65 aperture. Scanning optics 28 allow the detector 25 to scan the surface of the substrate 5 and   65

may be linked to that of the laser scanning optics 22.

A control unit 30, e.g. a computer, is linked to each valve 13, 14, and 15, pump 8, 9, oven 16, gun 18, heater 7, optics 22, 28, laser 20 and detector 25 to control growth of layers as described below. Additionally a cathode ray tube (CRT) 31 or graph plotter may be used to
5 provide a visual display of the detector output and allow manual control of the apparatus in   5
cleaning and growing layers. An additional laser (not shown) may be used as a second light source to modulate growth i.e. photo assisted processing.

Specularly reflected light R, may be detected and used in a feedback loop to stabilise the laser 20 output power. Additionally specular reflected light may also be detected and used to allow
10 for unwanted coating of windows 23, etc. Such a coating may build up from unwanted deposi-   10
tions of materials within the chamber 1. This compensation for window coating may employ light from the laser 20 or a further laser directing light through the window 27. In this latter case the specular light would also be received through this same window 27.

The apparatus of Figs. 1, 2 can be used to process silicon wafer substrates for devices at a
15 lower temperature eg 850°C instead of the more usual 1,000°C. Principal stages in the reduced   15
temperature silicon epitaxy are:—

(1) Substrate pre-clean, e.g. the known RCA clean, outside the chambers;

(2) Substrate surface oxide removal in the growth chamber 1 or in chamber 2 e.g. sputter clean;
20 (3) deposition and/or doping on the substrate in the growth chamber 1, using CVD or MBE   20
techniques.

Example of growing epitaxy layers of silicon using CVD techniques.

Step 1.
25 Clean a silicon wafer using R.C.A. technique or rinsing in aqueous H.F. followed by rinsing in   25
deionised water and drying.

Cleaning with the R.C.A. technique leaves a layer of thermally labile oxide that is relatively easy to remove.

30 Step 2.   30
Load cleaned wafer into loading chamber and reduce pressure to $\sim 10^{-7}$ mB.

Step 3.
Load wafer into evacuated growth chamber and flow H2 whilst operating pump 8 to maintain
35 pressure at about 10^{-7} mB (1 Torr.).   35

Step 4.
Initiate scatter measurements by illuminating an area of about 0.1 cm² by the laser and detecting scattered light.
40   40
Step 5.
Heat wafer with heater 7 to 850°C at a slow rate. The point at which the wafer substrate reaches 850°C is indicated at 0 on Fig. 3. This indicates the start of oxide desorption at the area of laser illumination.
45 Heating continues for about 5–15 minutes whilst the oxide continues to be desorbed and the   45
light scattering increases due to increasing roughness of the oxide and substrate surface. Point A on Fig. 3 indicates the break up of the oxide layer. If the cleaning step is continued the surface roughness increases to point B. After point B the temperature of the wafer has been reduced to about 825°C and the surface roughness is seen to remain reasonably steady.
50 If the oxide layer is a native oxide then a higher temperature is needed to remove it in the   50
same time. A native oxide can also be removed by reactive etching using an element which itself produces a volatile oxide. A convenient reaction in silicon epitaxy uses silicon atoms:—

$$Si + SiO_2 \xrightarrow{\text{800–850°C}} 2SiO \uparrow$$

55   55

The silicon atoms can be generated from thermal decomposition of a low SiH_4 flux. In an M.B.E. process the atoms could be produced from an e-beam hearth.

A similar graph is obtained for other wafers as shown in Figs. 4(a), (b) and 5(a), (b). Break up
60 of oxide is observed at A and roughness increases towards B.   60

Step 6.
To grow a layer of silicon on the cleaned surface the gas silane (SiH_4) is admitted at a typical rate of 1–100 sccm (standard cubic centimetre per minute) in excess H_2 with the pressure
65 remaining at 10^{-7} mB.   65

The effects of silane are observed at point B in Fig. 4(a), (b), the drop in scattered light is
considered to be a smoothing action of growing silicon. A short time later, at point C, nuclea-
tion has started and the scattered light reaches a high value. Thereafter the growing surface
becomes smoother and scattered light reduces to point D. Figs. 4(a) and 4(b) are for similar
5   wafers but measured in orthogonal directions.   5
For semiconductor epitaxy the preferred growth mode is by two-dimensional propagation of
lattice steps. This growth mode favours atomically-flat interfaces and uniform dopant incorpora-
tion, both very important for e.g. superlattices. For a crystal plane only slightly off the <100>
plane the substrate surface will be a series of steps typically about 1,000 Å wide and about 5
10 Å high. Under particular growth conditions periodic linear arrays of steps can be produced on   10
the growing surface.
Nomarski interference microscopy and surface profiling indicate these step arrays to have a
peak valley depth of about 3nm and a period of about 1 um. The formation and propagation of
such step arrays is easily detected as shown in Figs. 4(a) and 4(b). In Fig. 4(a) the peaks and
15 valleys 32 are normal to the direction of the laser light 21. In Fig. 4(b) the peaks and valleys 32   15
are parallel to the laser light 21. This is indicated at the top right hand corner of the graphs. A
flat 33 on the circle indicates the <110> crystalline direction.
As seen in Fig. 4(a) the growing surface becomes smoother after nucleation at point C until a
low point is reached at D. Thereafter the surface scatter increases up to point E as the effects
20 of peaks and valleys become more pronounced. This results from strong diffraction of the laser   20
light in the direction of the detector by the periodic step array. In Fig. 4(b) the growing surface
after nucleation at C becomes smoother up to point D and the scatter remains approximately the
same as the layer continues to grow out to point E. For this orientation the periodic step arrays
do not diffract in the direction of the detector. Thus for some applications it is necessary to be
25 able to rotate the direction of the laser light 21 relative to the growing layer to obtain maximum   25
information.
A further feature readily observed during growth is the quality of growing layer. This is seen in
Figs. 5(a), (b) taken with Fig. 5(c). Fig. 5(c) shows growth rate plotted against growth tempera-
ture derived from experiments on C.V.D. using SiH_4. A boundary line is seen that divides good
30 quality epitaxial growth from poor quality high defect level growth. The sample shown by Fig.   30
5(a) was cleaned at 860°C and grown at 820°C using a silane flow of 10 sccm and H_2 flow of
400 sccm. In Fig. 5(a) the removal of oxide is seen at point A and the introduction of silane at
B. Nucleation at C was followed by growth with continued reduction in measured scattered light.
The sample shown by Fig. 5(b) was cleaned at 860°C and grown at 755°C using a silane flow
35 of 10 sccm and H_2 flow of 400 sccm. After introduction of silane at point B nucleation occurs   35
at C. Thereafter the growing surface remains at a high scatter level due to the many surface
defects. Thus the quality of growing surface can be measured in real time and any corrections
made as they become necessary.

40 Step 7.   40
Stop silane flow when the desired depth of silicon has been grown.

Step 8.
Different gases may be flowed into the growth chamber to grow different layers. For example
45 silane plus a dopant such as diborane may be used to grow a doped layer. The growth of this   45
and any subsequent layers is monitored by scattered light as above. This technique is likely to
be very useful for complex structures, e.g. superlattices, where many process changes have to
be made, and monitored.

50 Step 9.   50
Remove wafer from chambers.
Example of growing layer of silicon on silicon wafer using MBE techniques.

Step 1.
55 Load wafer of silicon into loading chamber, reduce pressure to $\sim 10^{-7}$ mB to degass wafer   55
and chamber.

Step 2.
Transfer wafer into growth chamber 1 held at a vacumn of $\sim 10^{-10}$mB by the pump 8.
60   60
Step 3.
Illuminate a small area of wafer with laser light and measure the non-specular scattered light.

Step 4.
65 Slowly raise the temperature of the wafer to 850 C with the heater 7. Figs. 6, 7, 8 show   65

wafers being processed by MBE. Up to point 0 the scattered light remains reasonably constant
as the wafer heats up.

Step 5.
5   Open the shutter 17 to allow silicon from the Knudson oven or other Si source to flow onto   5
the wafer. A typical rate is about 5×10^{14} atoms per cm^2 per sec. The point at which the Si
shutter opens is indicated at point 0. Thereafter there is a short induction period during which
the native oxide is etched according to the reaction

10                        $$(850°C)$$ 10
$$Si(beam) + SiO_2 \longrightarrow 2SiO\uparrow$$

    As the last of the oxide is being removed there is an increase in light scattering. At point A
there is a peak in the scattered light analogous to the peak A in the Figs. 4. Thereafter the
15   scattering increases to point C where nucleation occurs and layer growth commences. This peak   15
appears much wider than those in CVD growth due primarily to the low growth rate in MBE
deposition; typically about 1 Å per sec.

Step 6.
20   Close Si shutter after the required amount of Si has been grown. Point B on Fig. 6 indicates   20
closing of this shutter.
    Fig. 7 indicates a slightly different procedure from the above. As before the Si shutter is
opened at point 0 and scattering increases. At point A the shutter 17 is closed. The light
scattered continues to remain reasonably constant until the shutter 17 is again opened at point
25   B still at 850°C. The further step in the curve perhaps indicates that oxide removal was not   25
initially complete. After point B the scattering increases due to nucleation to point C. Growth
follows until at point D the Si shutter 17 is closed. Scattering remains reasonably constant
afterwards.
    Fig. 8 indicates yet another different procedure. As before a wafer is heated to 850°C and the
30   Si shutter opened at point 0. Scattered light increases up to point A when the shutter is closed.   30
Between points A and B the wafer temperature is lowered to 825°C whilst the scattered light
remains constant. The Si shutter is opened at point B and nucleation and layer growth com-
mences. The scattered light is at a lower level than before. Subsequent measurements indicate
this signifies lower defect levels in the grown layer. Therefore the scattering at point A could be
35   taken as signal to close the Si shutter after cleaning to allow a reduction in substrate tempera-   35
ture for optimum nucleation and growth
    Using the apparatus with light scattering measurements as described above other phenomena
can be detected as follows:−
    1. Desorption of surface films from Si wafers at about 100°C. This typically shows as a
40   decrease in scatter intensity.   40
    2. Re-ordering of the amorphised surface of an Si wafer produced after oxide removal by ion
bombardment. If Ne+ ions at about 6 kV are used for sputtering the surface re-orders at about
620°C. Small peaks in scattering associated with this change have been detected.
    3. Increase in scattering have been observed when beams of MBE dopants, e.g. Ga, Sb
45   atoms, impinge on the Si surface. These atoms tend to accumulate on the Si surface. Sub-   45
monolayer coverage produces large changes in scattering.
    4. Emergence of the crystallisation front in solid phase epitaxy of Si. If Si is deposited on a
clean wafer at low temperature, say <300°C, it forms an amorphous layer. Raising the tempera-
ture to, say, >600°C will cause the amorphous layer to crystallise from the original interface.
50   When that recrystallisation front reaches the layer surface there is a large change in scattering.   50
    5. Accumulation of particulates on a surface. These tend to produce step increases in scatter-
ing intensity, and are very detrimental to layer quality.
    6. After nucleation has started scattering levels are observed that are periodic in time, e.g.
periods of 10 secs. These are related to growth rate and may be used to monitor thickness. For
55   example by counting a pre-determined number of periods and stopping growth or changing to a   55
different material.
    In general the light scattering technique will be most sensitive when the scatterers on the
surface have some dimension comparable with the wavelength. In the cases described above,
where the roughness in the direction normal to the wafer is on the nanometre or atomic scale,
60   strong scattering will requre the lateral dimensions of the surface roughness to be much larger,   60
e.g. 0.1 to 1 μm when using visible light. In the case where a growing layer is transparent to
light it is possible to obtain information at the substrate/layer interface.
    Using the changes in scattering shown in the Figs. 3 to 8 the control unit 30 can be
programmed to change the settings or operation of valves or Knudson ovens etc., to clean and
65   grow multiple layers automatically. This is especially useful when growing super lattice structure 65

with very thin multiple layers of different materials. It is also useful for V.L.S.I. devices where
many very thin layers are needed.

CLAIMS
New claims or amendments to claim filed on 9–7–87
Superseded claims NONE
New or amended claims:–
Claim 24 deleted.
1. A method of monitoring surface conditions on a surface of a substrate being processed
including the steps of:–
    directing a beam of light onto at least one small area of the surface being monitored;
    detecting light scattered from said small area in at least one non-specular reflection direction;
    changing the process parameters in response to detected changes on the surface.
2. The method of claim 1 wherein the substrate is mounted in a closed vessel.
3. The method of claim 1 wherein the inside of vessel is maintained at a reduced pressure
whilst gas is flowed over the substrate.
4. The method of claim 1 wherein the substrate temperature is changed in response to
changes in the detected light.
5. The method of claim 1 wherein the supply of material for coating the substrate is
switched on and off.
6. The method of claim 3 wherein the gas contains a gas of the material to be grown on the
substrate surface.
7. The method of claim 1 wherein the scattered light is detected from a number of non
specular directions.
8. The method of claim 1 wherein the beam of light is a beam of polarised light.
9. The method of claim 8 wherein the polarisation of the beam may be varied.
10. The method of claim 1 wherein the beam of light is scanned across a substrate surface.
11. The method of claim 1 wherein the beam of light is a continuous beam.
12. The method of claim 1 wherein the beam of light is pulsed on and off.
13. The method of claim 1 wherein the intensity of incident reflected light is also detected
used to stabilise the illumination on the substrate.
14. The method of claim 1 wherein different wavelengths of light are used to illuminate the
small area of substrate.
15. Apparatus for monitoring surface conditions of a substrate including:–
    a closed vessel capable of holding a substrate to be processed,
    means for cleaning or otherwise preparing a surface of the substrate,
    means for depositing a layer of material on the cleaned surface,
    characterised by:–
    means for directing light onto at least one small area of the surface less than the total area of
the surface,
    means for detecting light scattered from the small area in at least one non-specular reflection
direction,
    means for changing the cleaning or layer growth parameters in response to detected changes
of scattered light.
16. Apparatus according to claim 15 including a laser for illuminating the small area of
substrate.
17. Apparatus according to claim 15 including means for scanning the laser light across the
surface of the substrate.
18. Apparatus according to claim 15 including means for flowing gases through the closed
vessel, and for removing exhaust products from the closed vessel.
19. Apparatus according to claim 18 wherein the means for changing the cleaning or layer
growth parameters includes means for controlling the supply of gases through the chamber.
20. Apparatus according to claim 15 wherein the means for changing the cleaning or layer
growth parameters includes means for controlling the substrate temperature.
21. Apparatus according to claim 15 including means for detecting specularly reflected light
from the substrate and controlling the laser to stabilise its light output power.
22. Apparatus according to claim 15 including means for detecting non-specular reflected
light in a plurality of different directions.
23. Apparatus according to claim 15 wherein the means for detecting light includes a photo-
multiplier tube.
24. Apparatus according to claim 15 constructed, adapted and arranged to operate substan-
tially as hereinbefore described with reference to the accompanying drawings.