Dropouts and Algorithm Filters

for Improved Wafer Mapping Reliability

Tech Note by CyberOptics Semiconductor

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1. Purpose

Define dropouts and document algorithms that ignore dropouts and improve wafer mapping reliability.

2. Overview of wafer mapping

Wafers may be present in wafer carrier slots (see Figure 1). Each slot may have a status: present, absent or cross-slot. A cross-slotted wafer is supported by two different wafer carrier slots.

A sensor is moved relative to a wafer carrier during wafer mapping. Each scan starts with the sensor before the first wafer slot and ends with the sensor beyond the last slot (see dotted line in Figure 1). Scans may be upward or downward, but should always be in the same direction to minimize mechanical backlash, sensor latency and sensor hysteresis effects. The sensor indicates with the DETECT signal when a wafer is detected. The DETECT signal has only two possible states. Software receives data indicating the relative position of the sensor and the wafer carrier for each change of the DETECT signal. Software interprets the data to determine the status of each wafer carrier slot. A wafer map is a list of the states of wafer carrier slots. Slots are numbered starting from the bottom of a carrier, starting with the number 1. The carrier illustrated in Figure 1 has a map of: (from the bottom) Present, Absent, Present, Present, Cross, Cross, Present, Present, Absent, Present, Present, Absent.

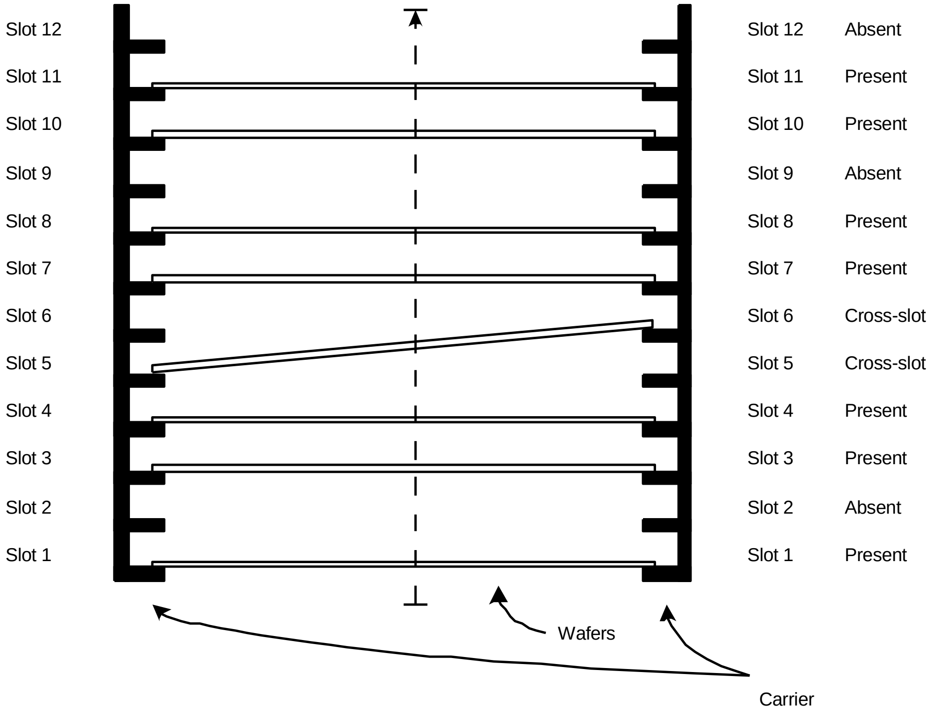

Figure 1. Wafer placement in wafer carrier

3. Dropouts

Ideal wafer mapping sensors turn on once as they approach the wafer and off once as they depart from the wafer. Wafer mapping software estimates wafer center location as the midpoint between these two positions. Reflective wafer mapping sensors operate by sending out an optical signal that is reflected from a wafer edge back to the sensor. Reflective sensors receive the reflected signal and use signal processing to convert the reflected signal into the sensor's DETECT signal. Through-beam wafer mapping sensors operate by sending out an optical signal that is attenuated by the cross section of a wafer. Through-beam sensors receive the attenuated signal and use signal processing to convert the attenuated signal into the sensor's DETECT signal. Both types of sensors output a DETECT signal that indicates wafer presence.

A dropout is a short distance during which the wafer mapping sensor DETECT signal is off. Sometimes, during the movement of a sensor past a wafer, the DETECT signal toggles more than once as the wafer is passed. The sensor DETECT signal is off for a short distance, even though the wafer is present. This is called a dropout. Figure 2 illustrates several dropouts. The dropouts are exaggerated for clarity.

A dropout can happen when the optical signal is noisy or uneven for a time longer than the response time of the sensor. This noisy or uneven optical signal can be caused by several things including: servo performance, mechanical vibration, wafer edge variation, electrical noise, or any other noise source in the wafer mapping system. This is more likely to happen at the top edge or bottom edge of a wafer because the signal amplitude is near the threshold of the sensor.

Small signal variations do not cause the DETECT output of the sensor the change because of sensor threshold hysteresis and sensor response time. Hysteresis is the difference in signal strength required to switch DETECT on and off (see Figure 2). Larger hysteresis stabilizes the DETECT signal but limits the ability of a sensor to respond to small changes in signal amplitude. In other words, excessive hysteresis can limit the dynamic range of wafer signal detection. Longer response time also stabilizes the DETECT signal but limits the ability of a sensor to respond to brief changes in signal amplitude. Sensor response time limits the maximum scan speed.

Signal amplitude variations greater than optimal sensor hysteresis and longer than the optimal sensor response time are observed as dropouts by wafer mapping software.

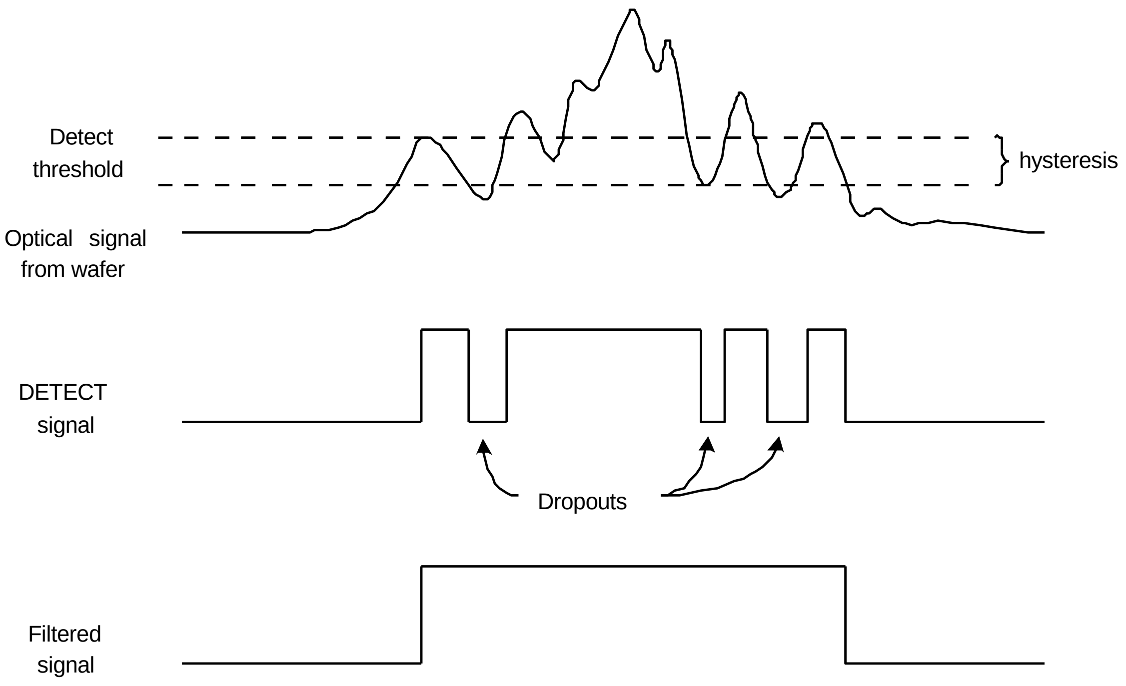

Figure 2. Detected signal example

Wafer mapping algorithm reliability can be improved by filtering the detected edge data to combine adjacent wafer detected signals. Figure 3 illustrates the data corresponding to various points in the wafer mapping process. This example assumes the wafer is 0.825mm thick. The first dip in the signal is deep enough and long enough to cause a dropout. The second dip in the signal is ignored by the sensor threshold hysteresis. An overall positional shift results from the response time of the sensor. If the un-filtered edge data was mapped, two wafers at 0.077 and 0.534 would be recognized. False cross slot errors would likely result from the recognition of an extra wafer. When the filtered edge data is mapped, one wafer is recognized at 0.434mm and the wafer will be correctly classified as present.

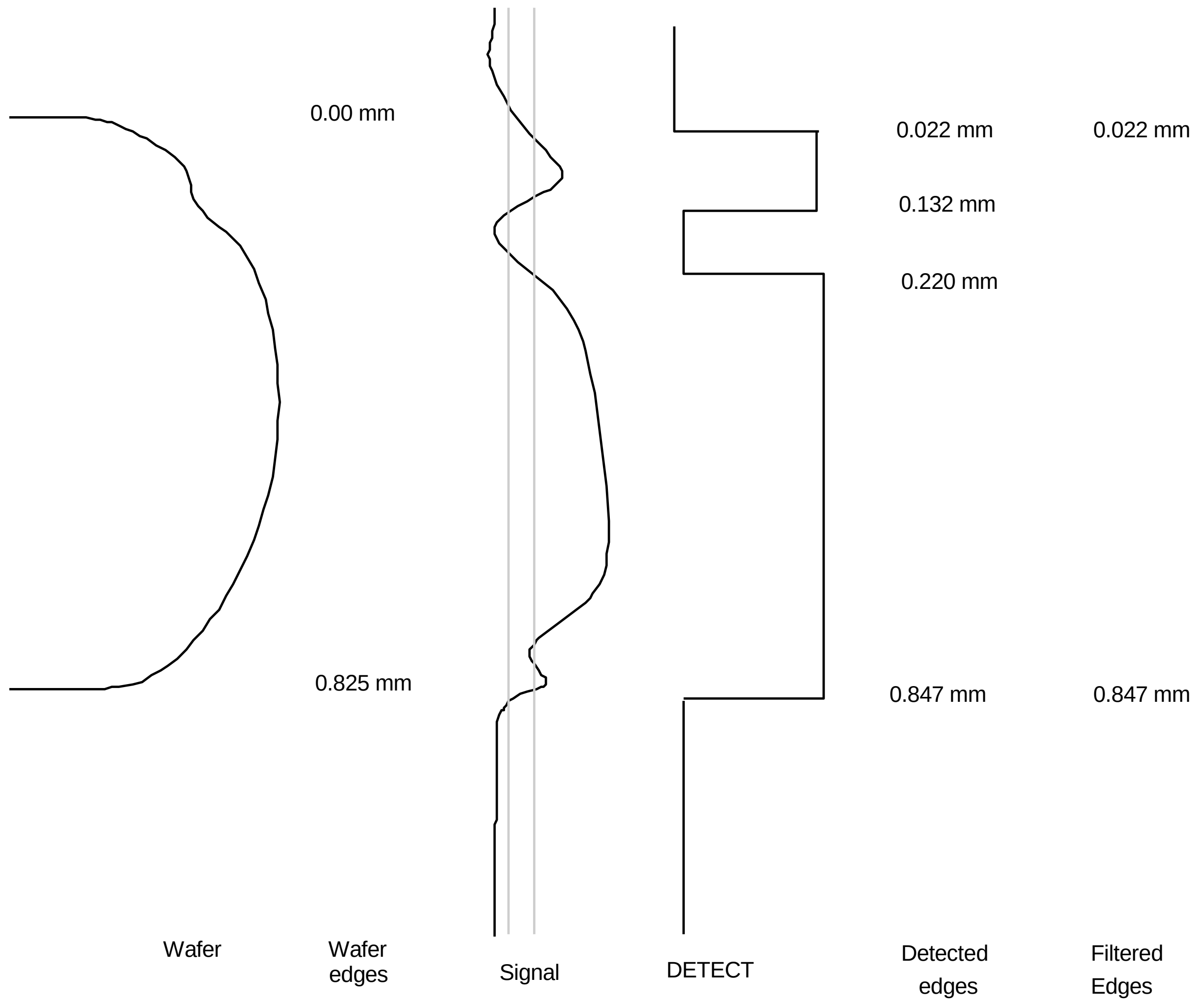

Figure 3

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Dropouts are small gaps in the DETECT signal while larger gaps correctly indicate space between wafers. A filter algorithm that removes dropouts of 1.0 mm or less works well for standard 200 mm wafers in cassettes and for standard 300 mm wafers in FOUPs. The 1.0 mm threshold may need to be adjusted in special cases that may include (1) slot spacing less than 6.35 mm (normal slot pitch is 6.35 mm for 200 mm cassettes, and 10.0 mm for 300 mm FOUPs), (2) slot shape allows wafers to be positioned so that they are not quite flat, or tipped down in front, and (3) thin wafers that sag or bend under their own weight.

4. Drop-Out Filter Algorithm in ANSI C

```
#include <stdio.h>
#include <stdlib.h>


//
//          This function will get rid of drop out gaps of sizes smaller than
//          user specified value “lMinimumGap”
//
//


//Note:
//The raw data from the robot must be data which consists of z-position of
//the signal transitions.


//Ideally the number of transitions should be an even number since each pulse has 2 edges
//top and bottom (or start and end)).  Otherwise there is a problem since with the drop //outs we can’t tell if
current edge data is beginning of a signal pulse or the end.


//We always assume the first data is either:
//1. bottom edge of lowest slotted wafer if scanning from bottom to top
//or
//2. top edge of highest slotted wafer if scanning from top to bottom
```

```
//***
long   DropOutFilter(long*  lpData,                    //array of raw z data after the scan
                        long   lDataSize,              //size of this array
                        long     lMinimumGap)          //minimum gap size allowed
{
        long   i;                 //index into lpData
        long   j;                 //index into “lpNewData” buffer
        long   gap;               //gap size
        long*  lpNewData;         //buffer that holds new filtered data
        long   new_size;          //size of filtered data




        //create temporary buffer that will hold processed data
        lpNewData = (long*) malloc(sizeof(long) * lDataSize);

        i=0;     //index to first z data in lpData
        j=0;     //index to first data in lpNewData

        lpNewData[0] = lpData[0];                //copy first wafer edge

        j++;                                     //index to next edge

        //go through all the edges in pairs
        for(i = 0; i < ( lDataSize-2 ) ; i += 2){

                //get the gap size
                gap = labs( lpData[i+2] - lpData[i+1] );

                //check if the gap is smaller than lMinimumGap if(
                gap >= lMinimumGap){
                        //if gap is big enough copy this gap to new buffer lpNewData
```

```
lpNewData[j] = lpData[i+1];
                j++;
                lpNewData[j]   =   lpData[i+2];
                j++;
                //note that j will increment only when gap large
                //enough to be a another wafer is detected
        }

}//for next

//copy the last z data
lpNewData[j] = lpData[lDataSize-1];

//number  of  edges  in  filtered  data
new_size = j + 1;



//clear original data
for(i  =  0;  i  <  lDataSize;  i++){
        lpData[i] = 0;
}

//copy new filtered data to lpData
for(j = 0; j < new_size; j++){
        lpData[j] = lpNewData[j]; }

//free   temporary   buffer   lpNewData
free(lpNewData);

}
```

5. Related Documents

EX Wafer Mapping Sensors *Instructions for Installation and Use*

WX Wafer Mapping Sensors *Instructions for Installation and Use*

SEMI E1.7-94 "Standard for 200 mm Plastic and Metal Wafer Carriers, General Usage (PROPOSED)"
Note: *This proposed standard failed to win industry approval. Standard development was abandoned after the industry was unable to reach a consensus. SEMI does not currently publish any standard for 200mm wafer carriers. The dimensions and tolerances of 200mm wafer carriers must be taken from each wafer carrier supplier's specifications.*

SEMI E1.9 "Mechanical Specification for Cassettes used to Transport and Store 300 mm Wafers"

SEMI M1 "Specifications for Polished Monocrystalline Silicon Wafers"

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