CHAPTER 5

CONCLUSION AND RECCOMMENDATION

5.1 Introduction

Reactive Ion Etching (RIE) is a chemical process, which has many process input variables as the following list.

- CF_4 Flow rate (sccm)
- Chamber pressure (mTorr)
- APC angle (degree)
- Peak to peak voltage (volt)
- Bias voltage (volt)
- Coil forward power (watt)
- Coil load (%)
- Coil tune (%)
- Platen forward power (watt)
- Platen load (%)
- Platen tune (%)

To meet the smooth etched surface all process input variables have to be well control and monitoring. The principal component analysis is suitable for this purpose because the general objectives of principal component analysis are data reduction and interpretation. For this reason all 11 process input variables was transformed into PC models and used for fault detection in shallow etching process. The result of this study revealed that PC model can detect faulty.

5.2 The Principal Component Model Generation

Based on normal data of 20 batches that we use as our database. All 11 process input variables were transformed into significantly 4 PC models (Fig. 5.1 to 5.4) with the percentage explained variance over 80% (Fig. 5.5). The model adequacy checking by using Hotelling and/or residual statistics showed these models were fit with the on-hand data of shallow etching process (Fig 5.6 to 5.7).

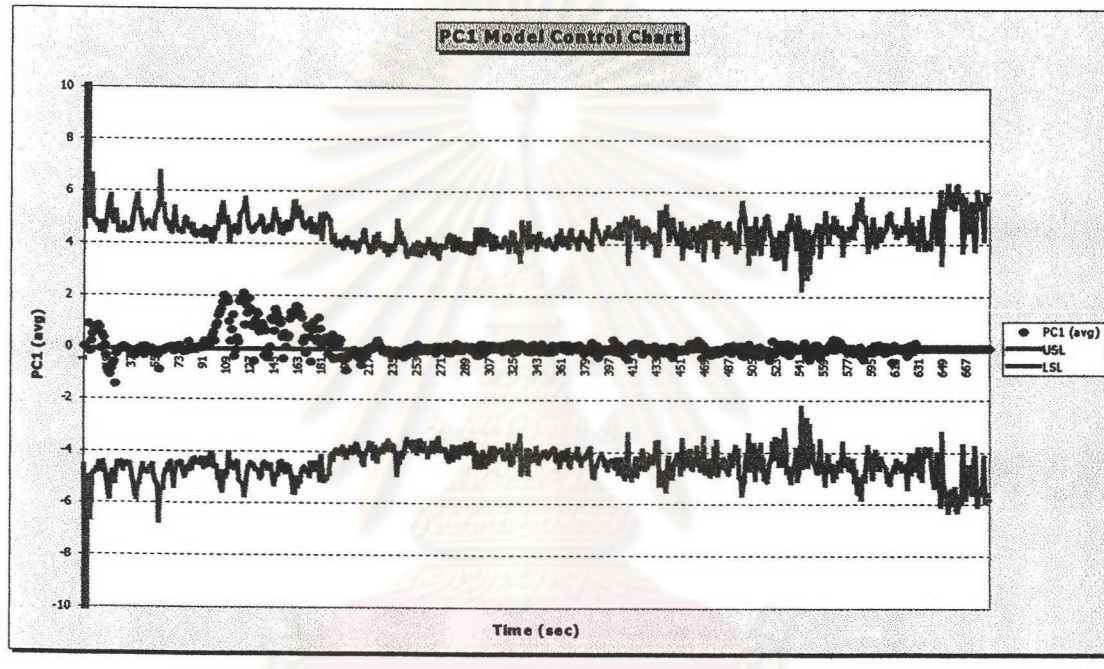

Figure 5.1 Solid model of Principal Component #1

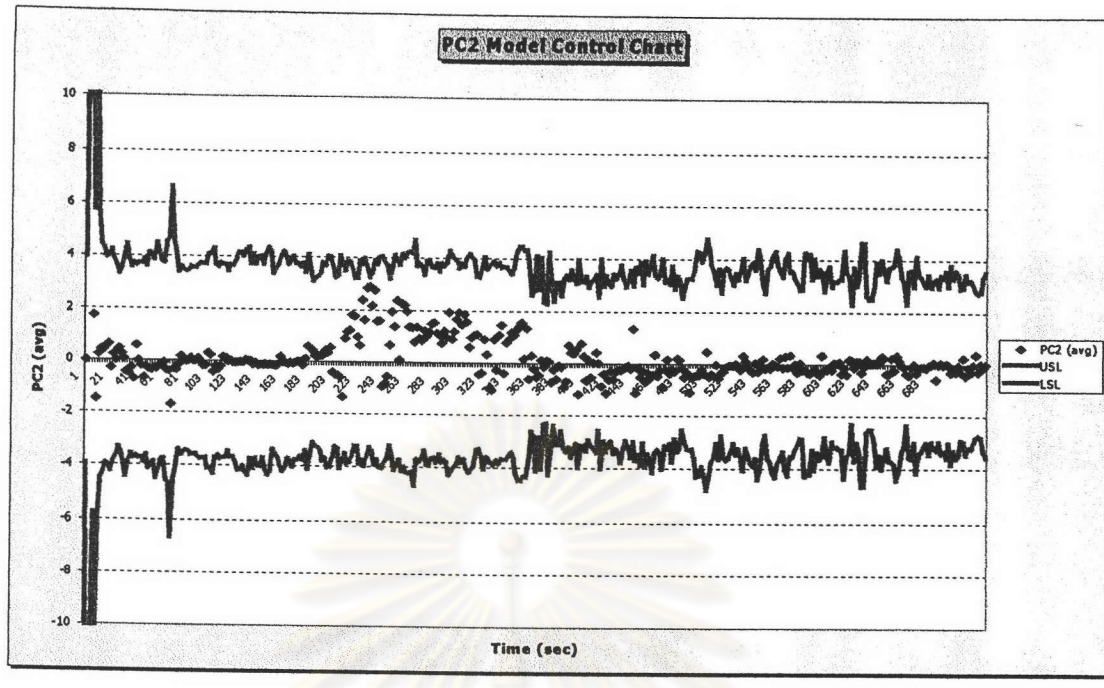

Figure 5.2 Solid model of Principal Component #2

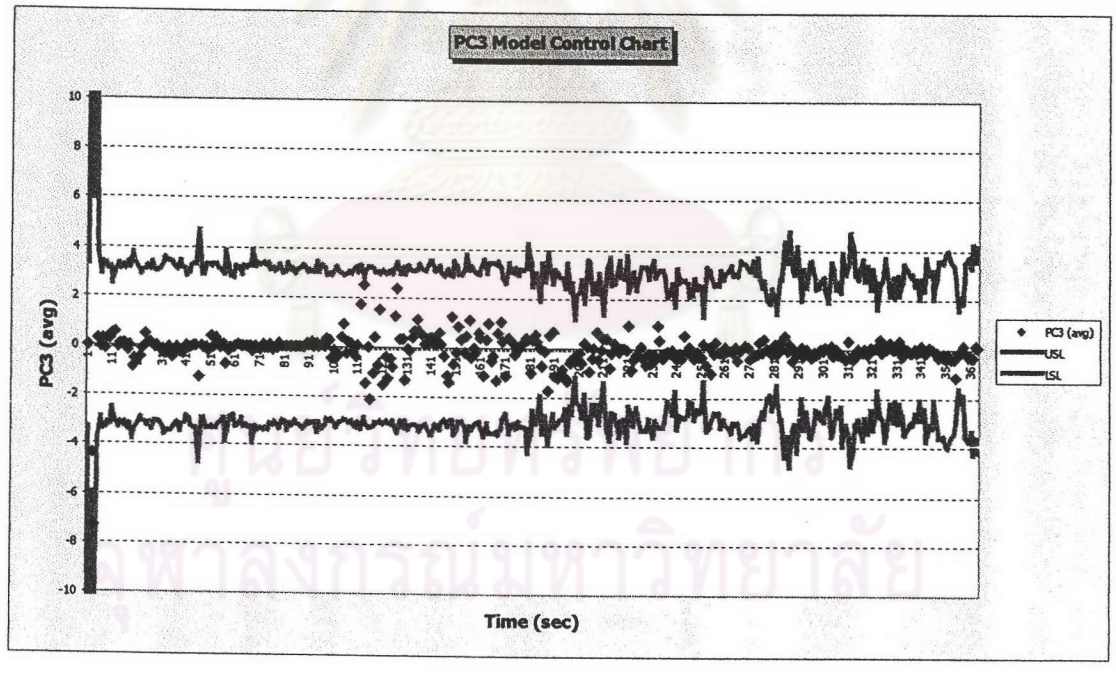

Figure 5.3 Solid model of Principal Component #3

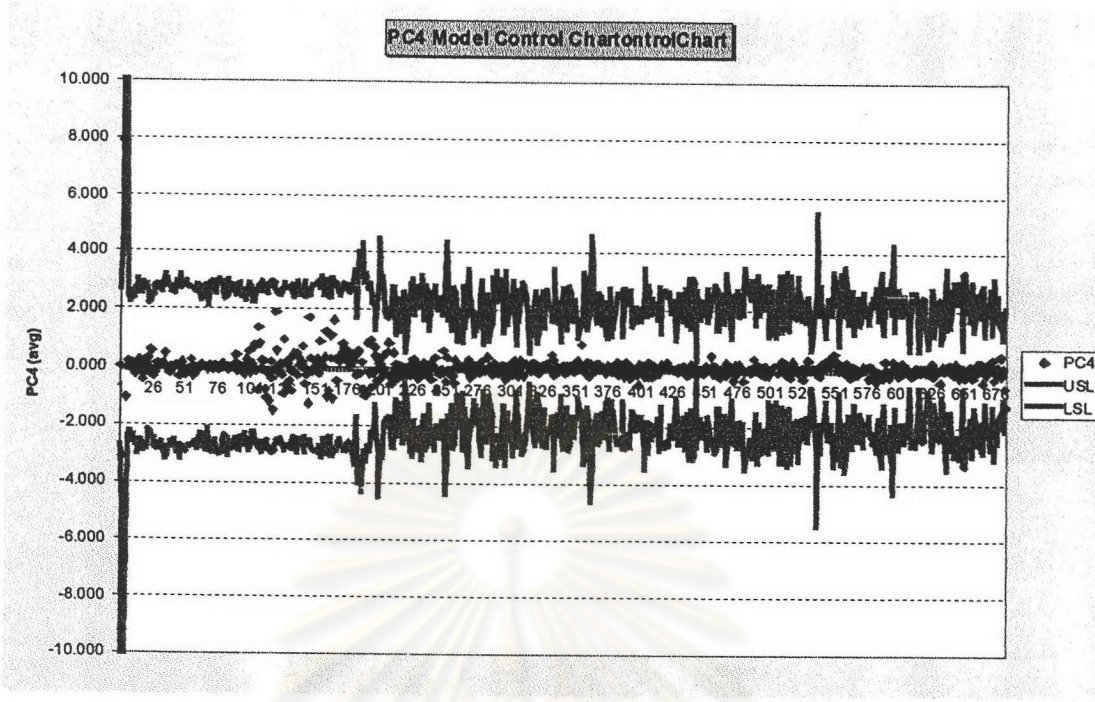

Figure 5.4 Solid model of Principal Component #4

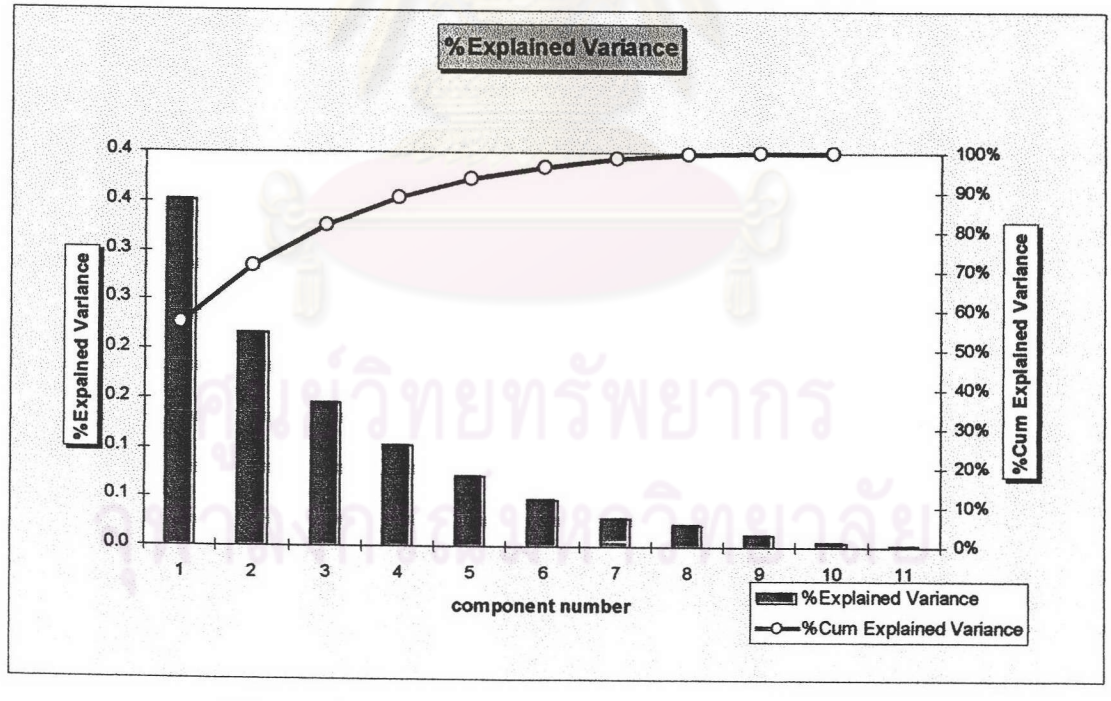

Figure 5.5 Percentage explained variance of all PC

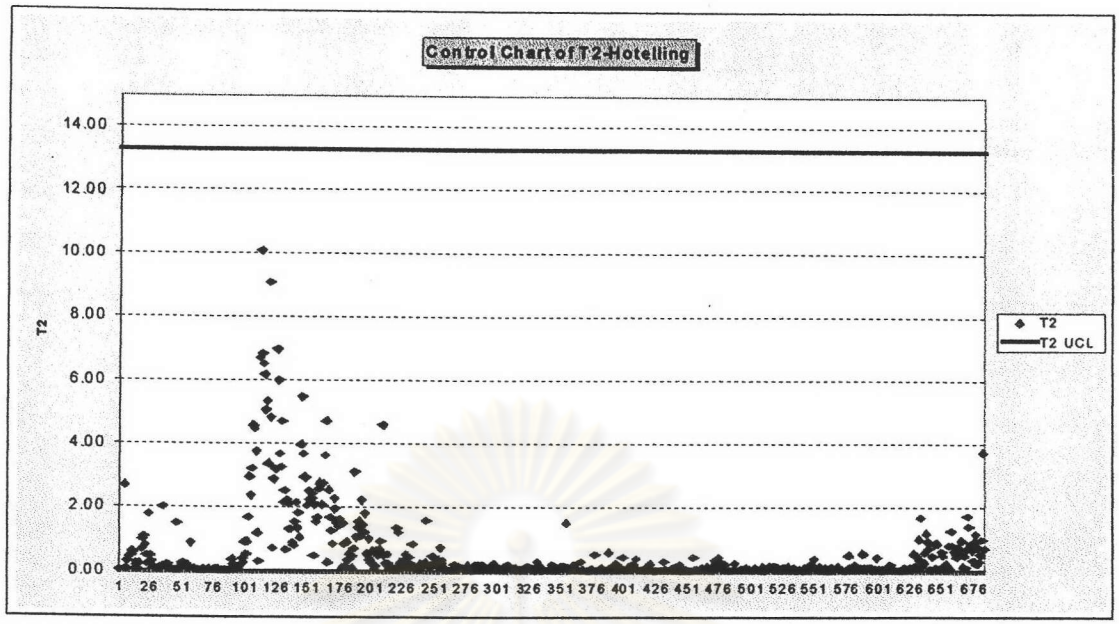

Figure 5.6 T^2 Hotelling Statistic Chart

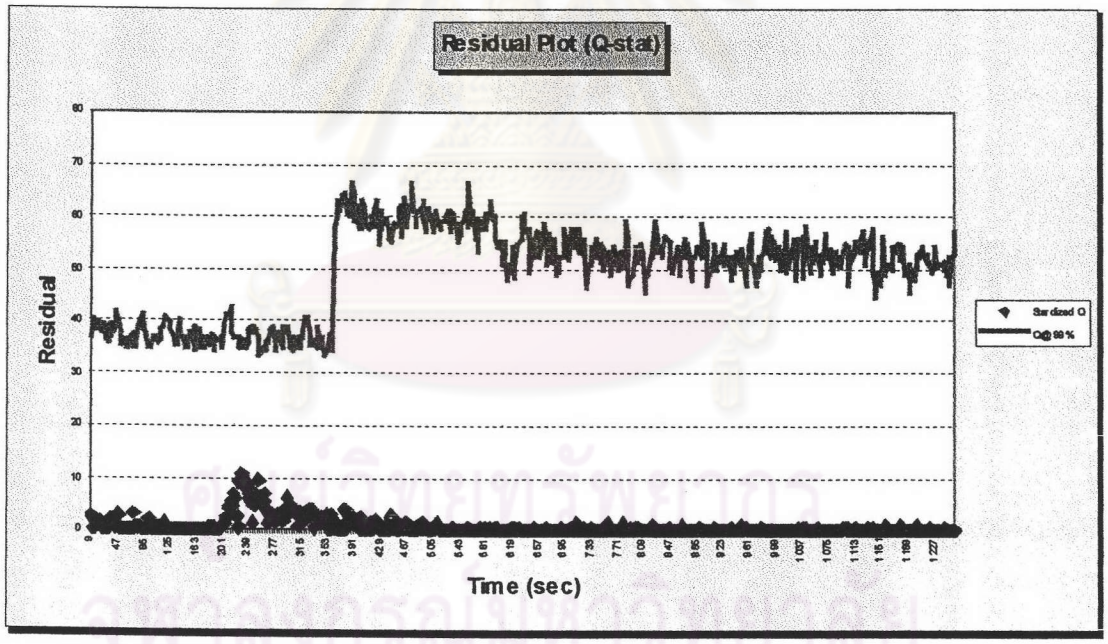

Figure 5.7 Residual Analysis (Q-statistics) Chart

5.3 The Model Validation on Actual Processing Data

Once the PC models were created, refer to item 5.2, so these models have to check the validation on actual processing data from shallow etch two additional batches; one is normal and another one is abnormal batch. The procedures of this step were follow the same as model generation except the control limit of each criteria. Because of the new batches data were running under the selected PC models.

Based on two additional batches data with 11 process input variables and 628 time interval, these data were scaled and applied into selected 4 PC models. From PC charts, there were obviously out of control in all PC charts of abnormal batch (Fig. 5.8 to 5.11), while the phenomenon would not found in normal batch (Fig. 5.12 to 5.15).

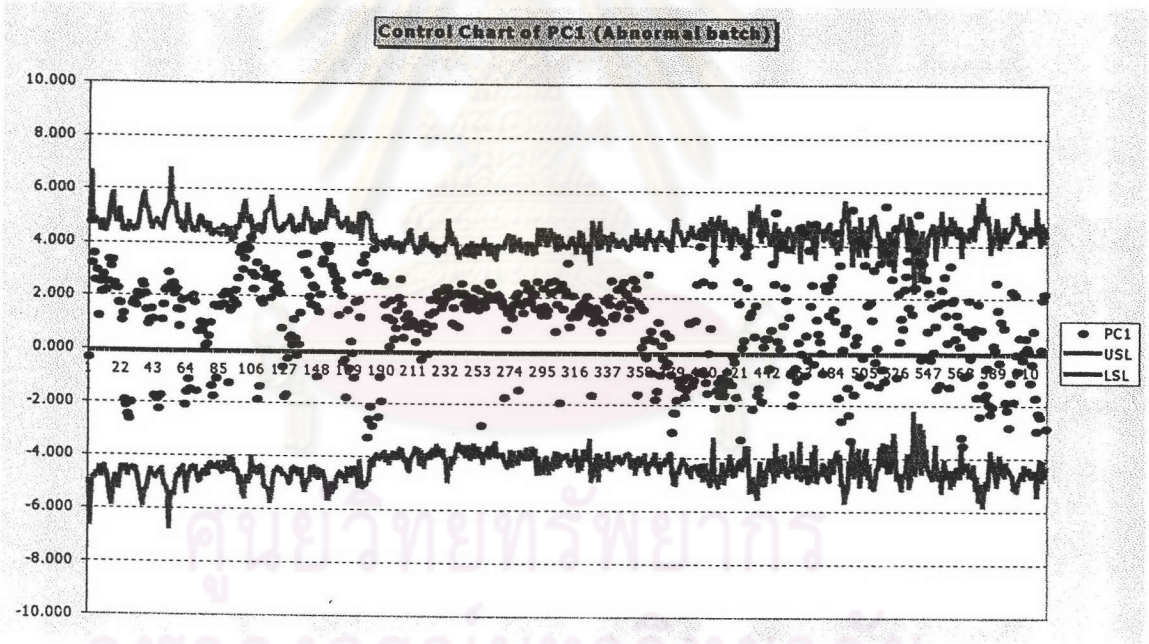

Figure 5.8 Principal Component #1 of abnormal batch

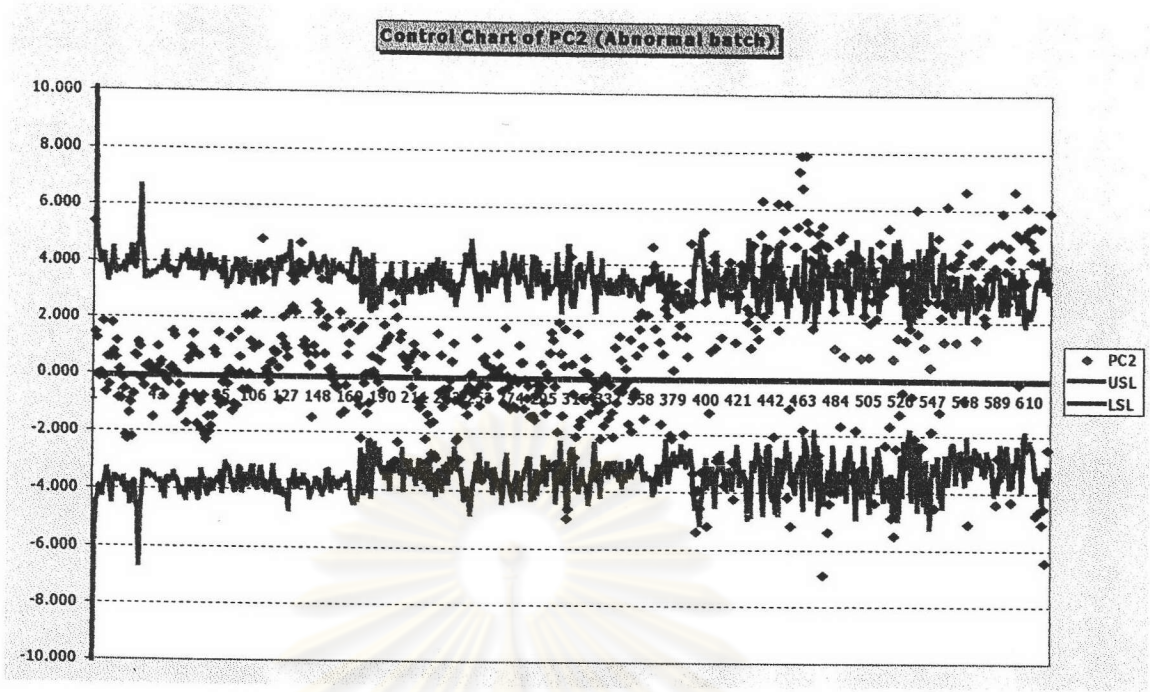

Figure 5.9 Principal Component #2 of abnormal batch

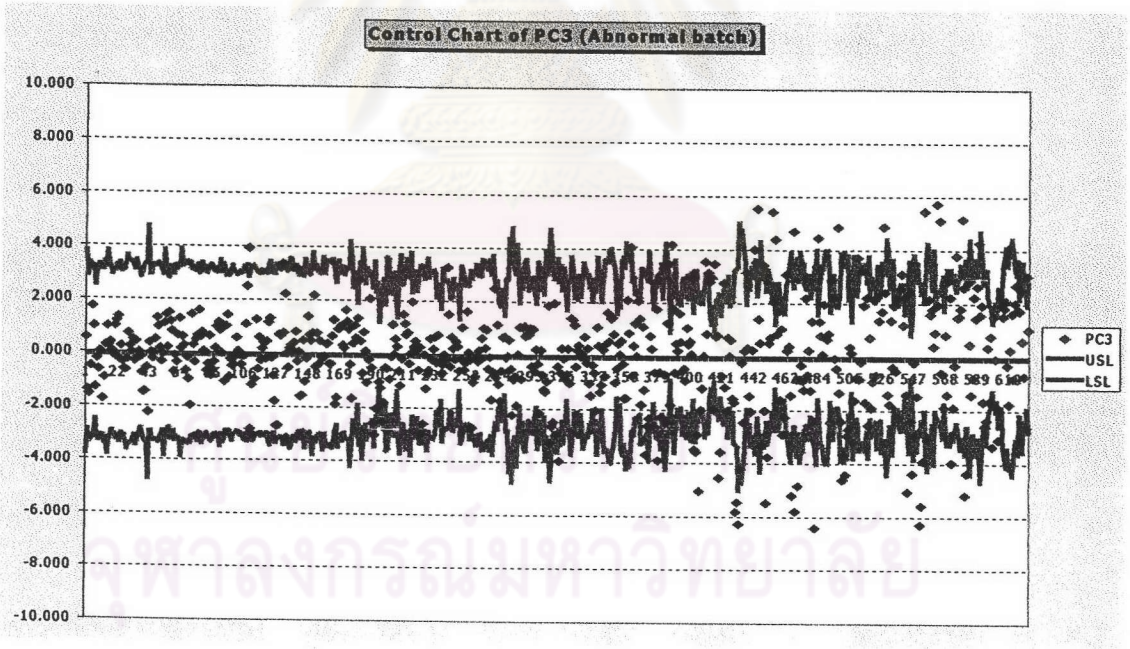

Figure 5.10 Principal Component #3 of abnormal batch

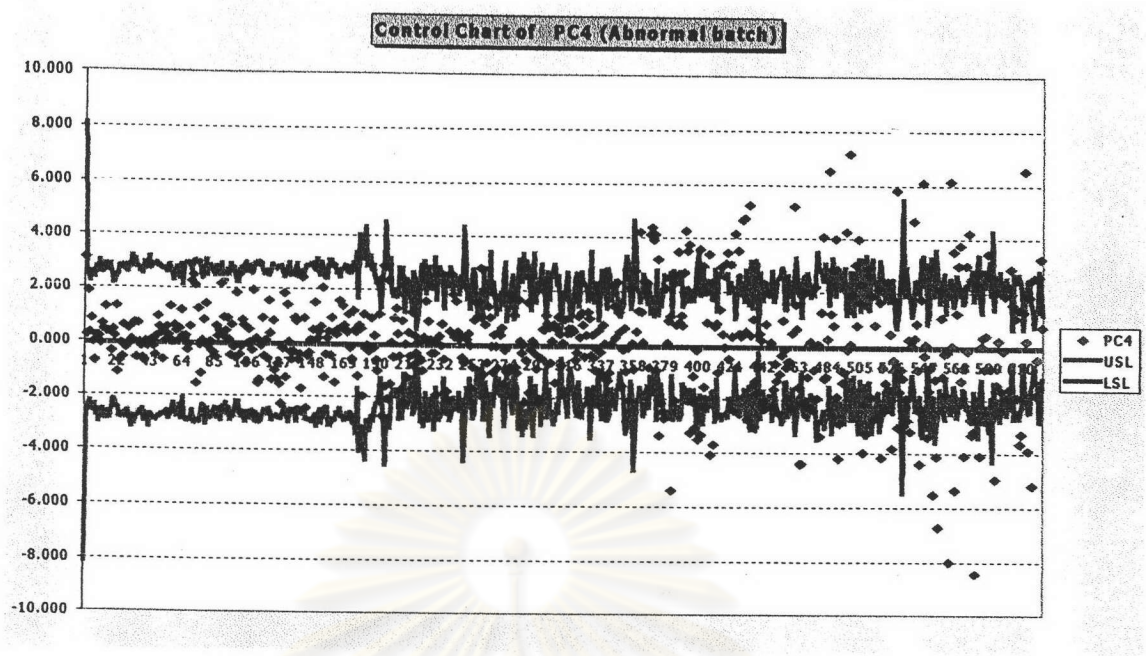

Figure 5.11 Principal Component #4 of abnormal batch

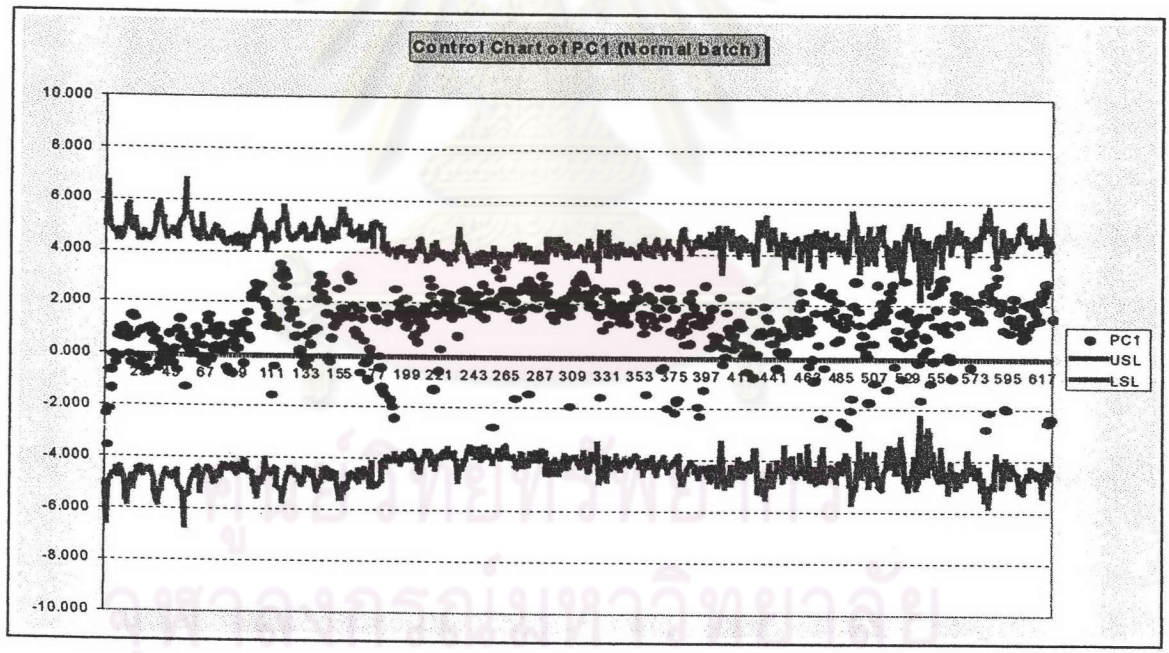

Figure 5.12 Principal Component #1 of normal batch

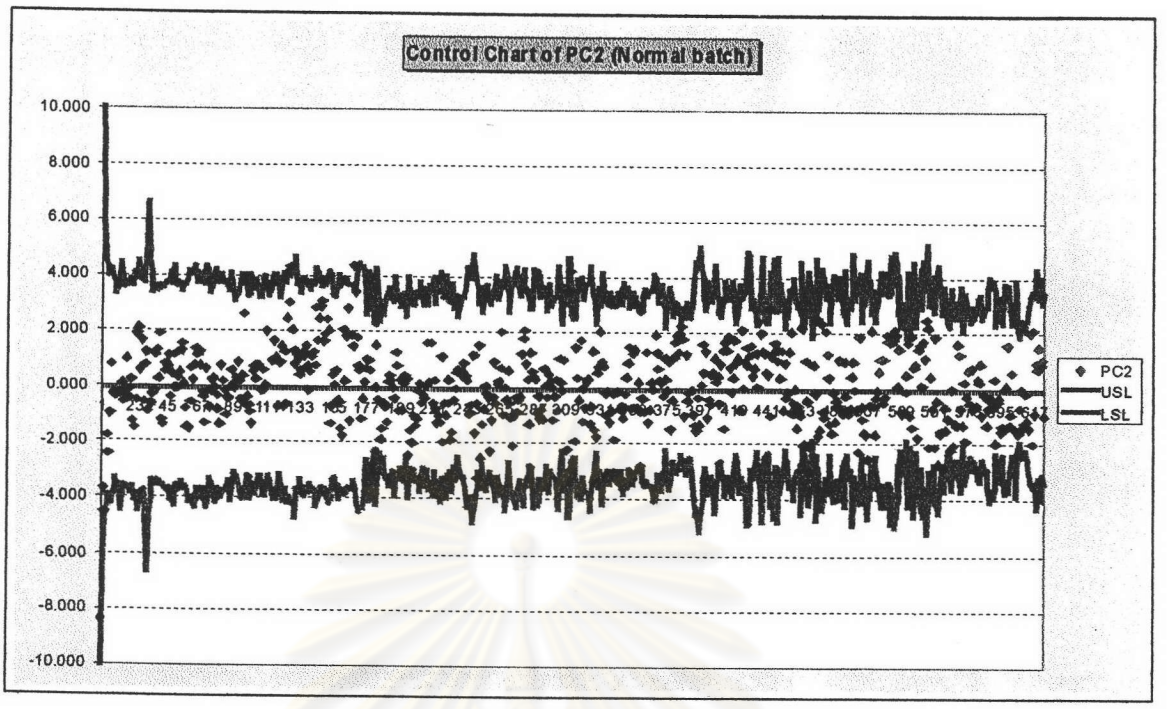

Figure 5.13 Principal Component #2 of normal batch

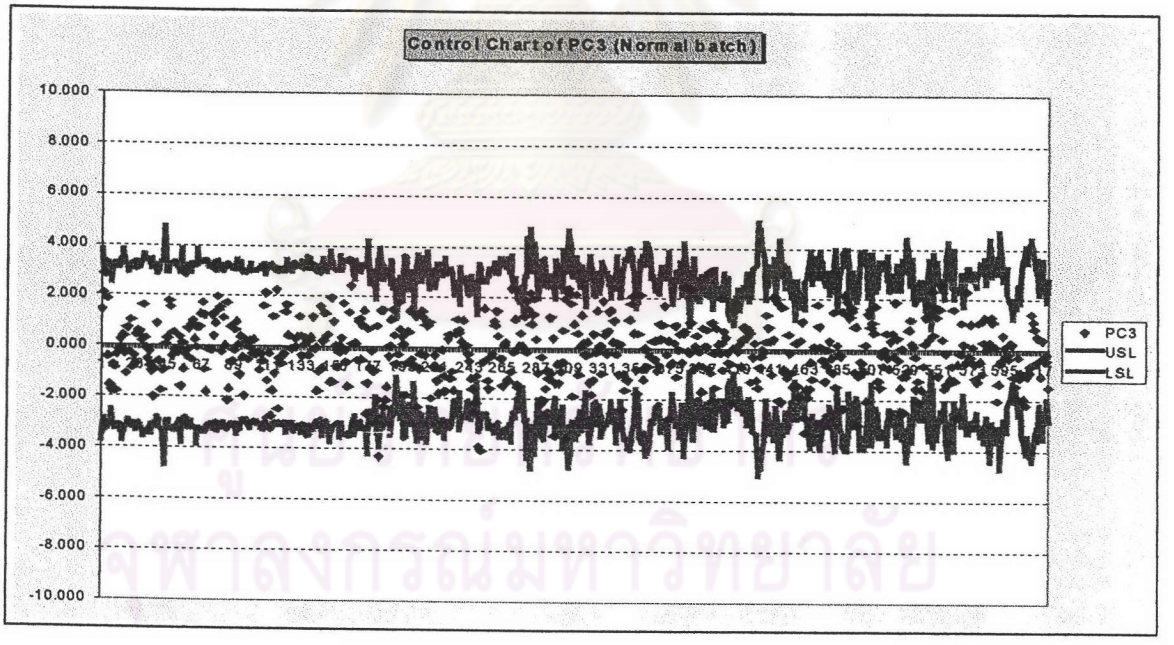

Figure 5.14 Principal Component #3 of normal batch

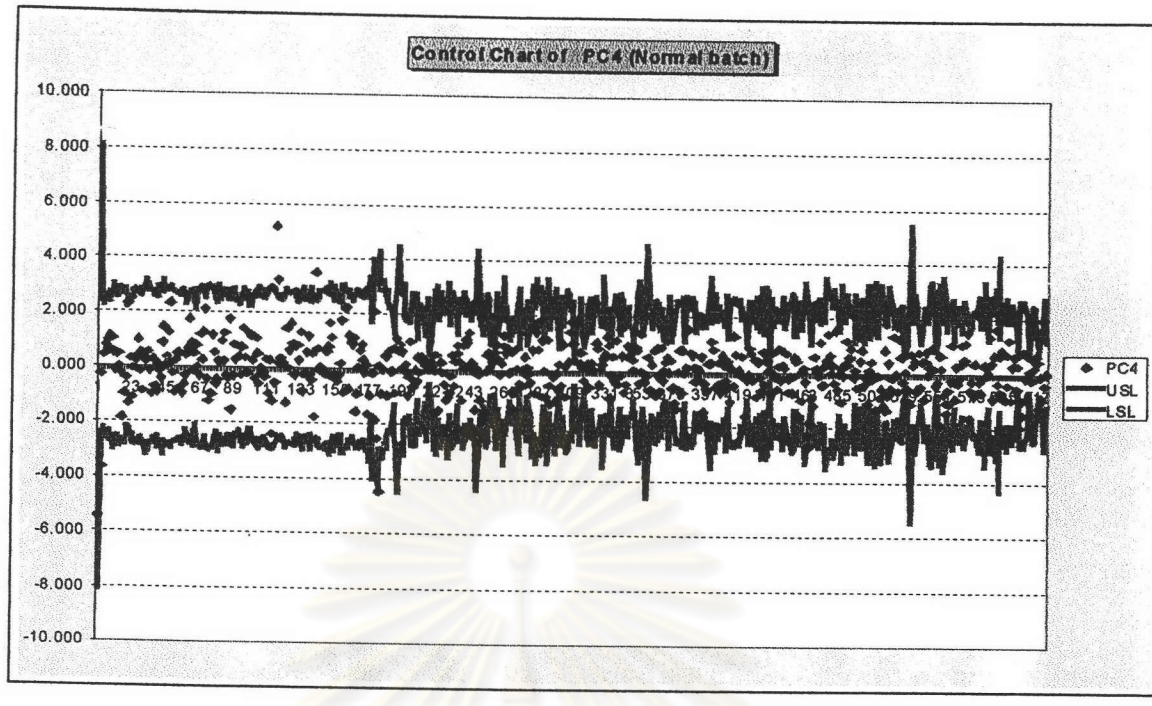

Figure 5.15 Principal Component #4 of normal batch

The model adequacy checking by using Hotelling and/or Residual statistics showed these models were fit with the on-hand data of shallow etching process (Fig 5.16 to 5.19).

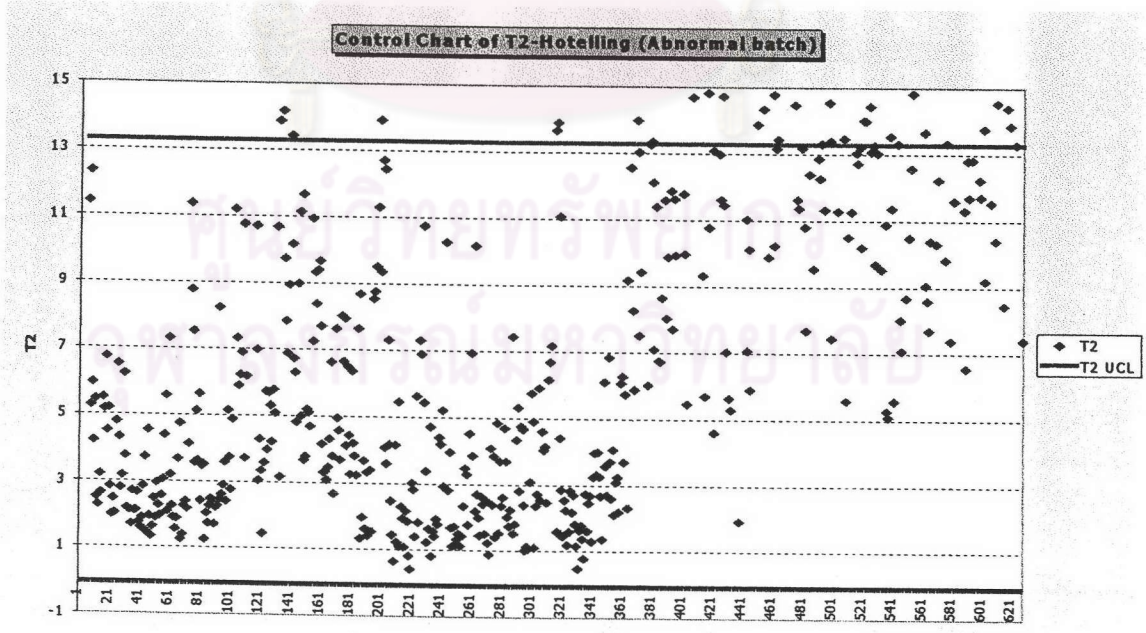

Figure 5.16 Hotelling Statistic (T^2) chart of abnormal batch

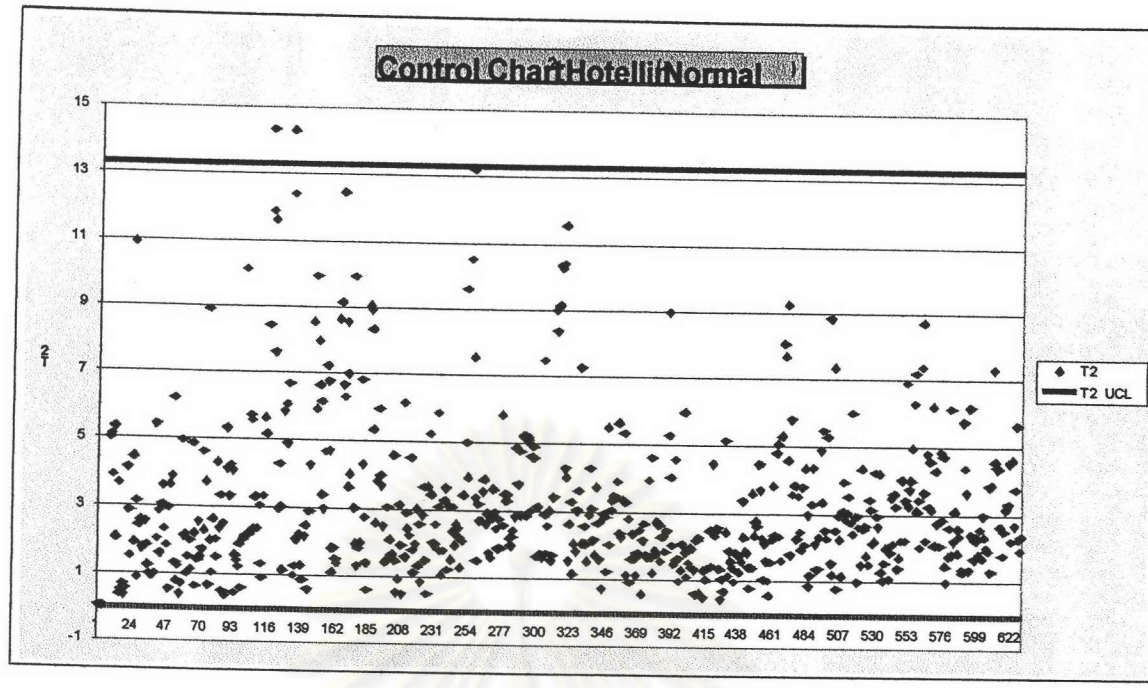

Figure 5.17 Hotelling Statistic (T^2) chart of normal batch

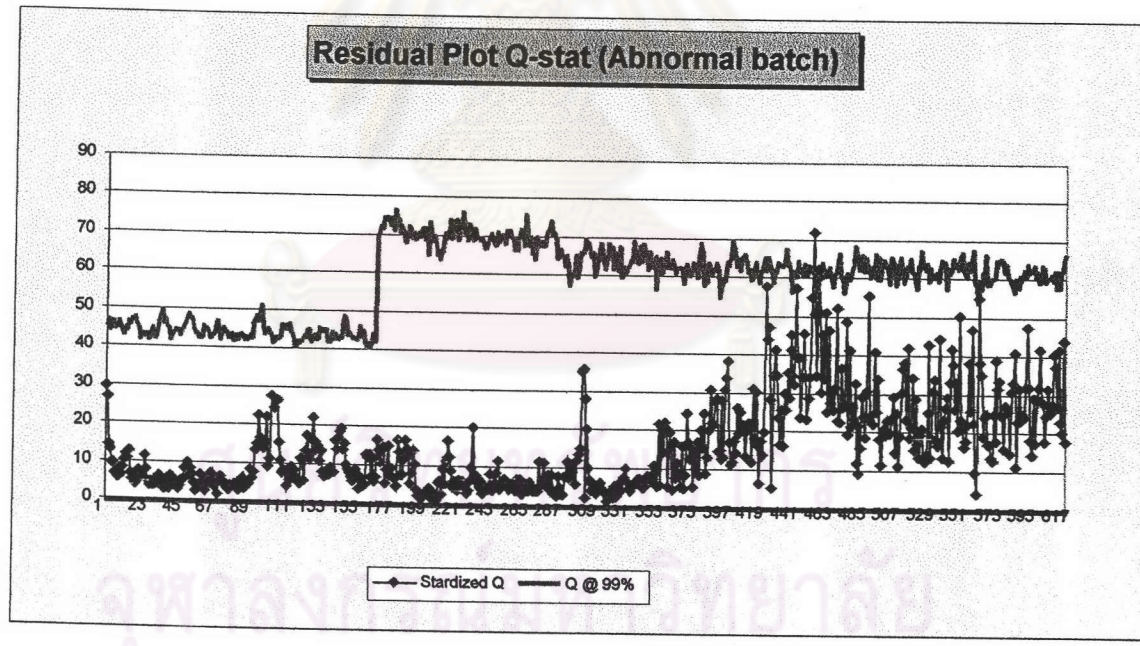

Figure 5.18 Residual Analysis (Q-statistics) chart of abnormal batch

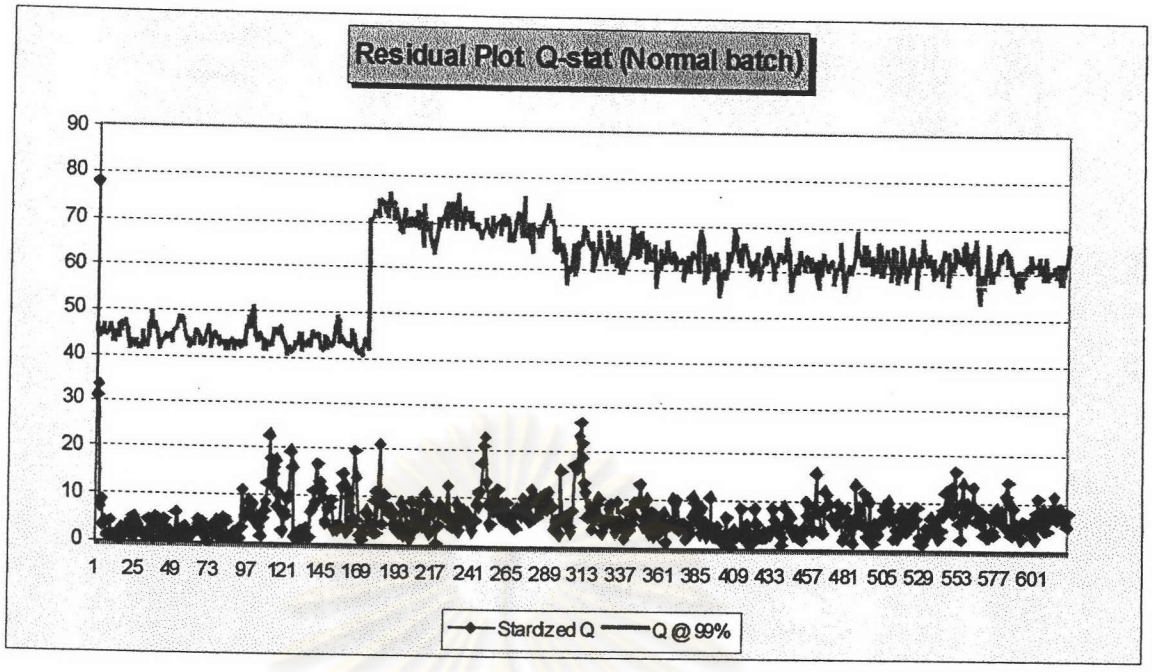

Figure 5.19 Residual Analysis (Q-statistics) chart of normal batch

The confirmation testing of 4 PC models in production run at same machine that we use in this study for almost four weeks show improvement in etched depth uniformity from 1.830 to 1.795 percent(Fig 5.20). Due to we had found problem that we can fix.

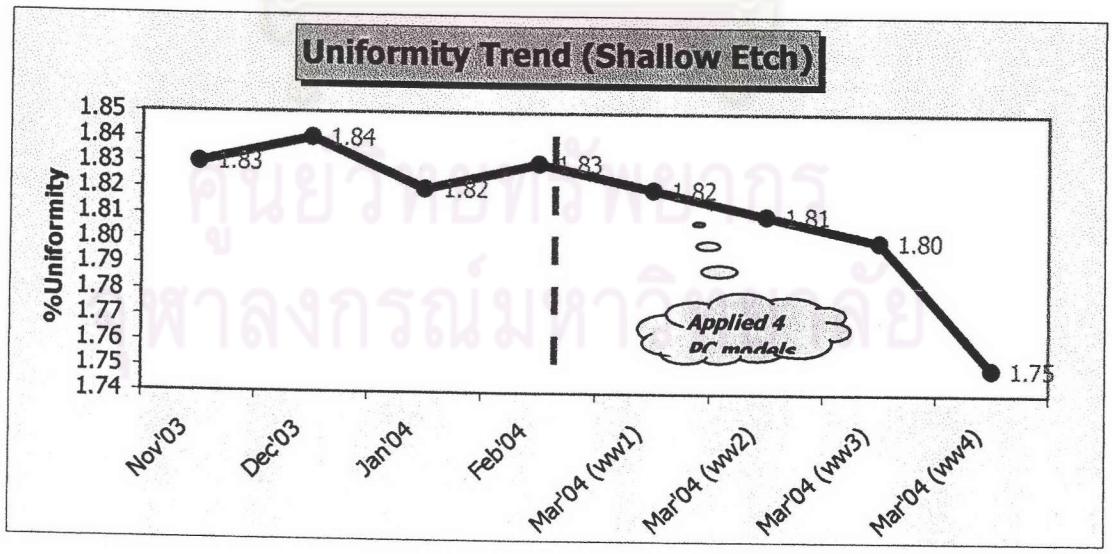

Figure 5.20 Etched depth uniformity trend chart

5.4 The constraint of this study

Due to the RIE equipment is old version, there is no free space in hard disk drive to install program and interfacing between new program and operating software are interfered. Also the same reason as mention before real time control by using PCA can not perform therefore this study is an off-line monitoring and control shallow etching process.

5.5 The recommendation

To develop the efficiency of PCA in order to monitor and control RIE process these are the recommendations for the further study.

5.5.1. This study is an off-line monitoring and control by using PCA model and the to improve the efficiency of fault detection the real time PCA should be created.

5.5.2. In this experiment, all of control limit were calculated for 99% confident level. It is good enough to detect any error. However, if we need more better quality control for our product. We can reduce confident level to 95% or 90% that can easily detect error.

5.5.3. As we mention in chapter 4, we select specific equipment, product specification. Principal component must be different also if we select another equipment or product specification.

5.5.4. Normally, some variables would be changed after chamber cleaning. So we might need to re-calculate principal component after cleaning process is done.