長晶製程參數智能化解析——斷線率改善與控制

智慧化企業整合

Intelligent Integration of Enterprise

- Project 3
- 108034541 周郁淇

Content

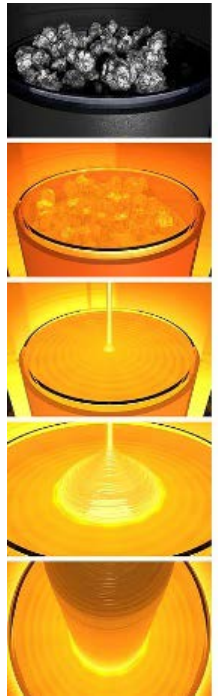
01

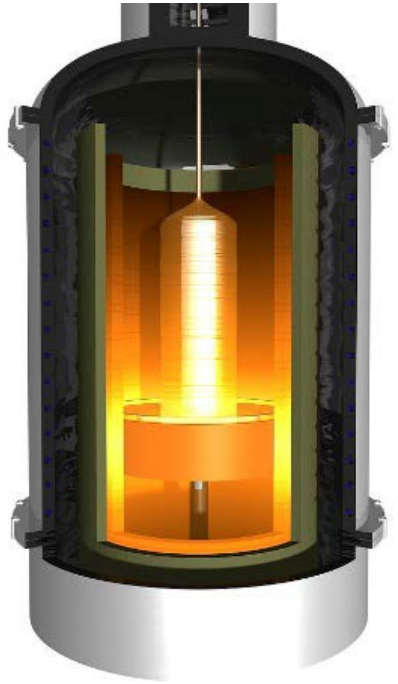
Scenario

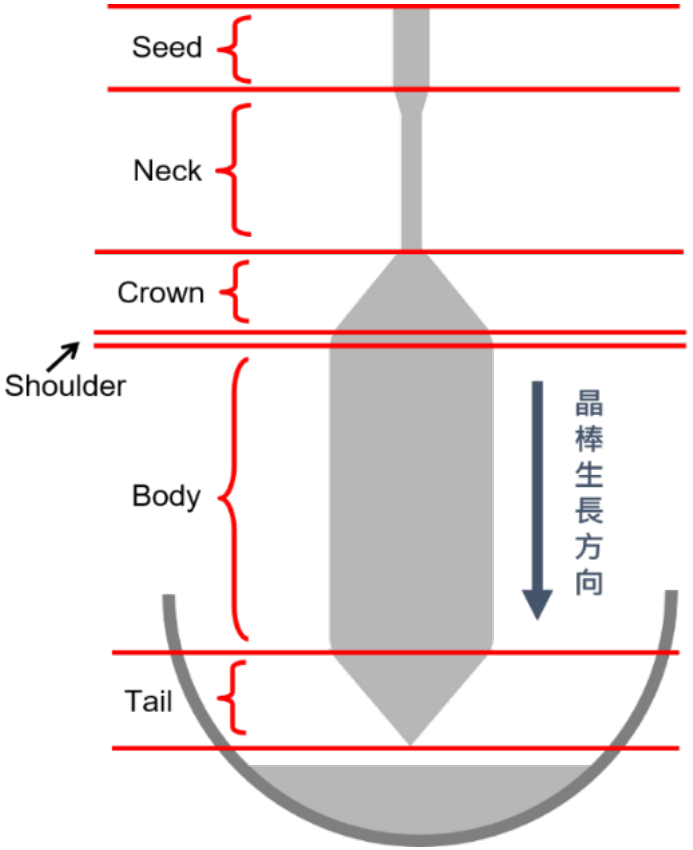
- Background
  - 5W1H
- Literature Review

Background

- 長晶製程
  - 填料、熔融、拉起
  - 晶頸→晶冠→晶身→晶尾
- 斷線
  - 晶線：晶棒結晶的稜線
  - 斷線：晶線不連續的現象
- 斷線重熔生長需1天以上工時
- 造成人力、設備成本消耗







5W1H

What

W

長晶製程斷線率

晶棒良率

When

W

晶棒生長的過程

Who

W

晶圓廠作業員

半導體公司

Where

W

晶圓廠長晶爐

Why

W

生長參數調整不當

晶棒斷線造成企業

成本增加

How

H

資料分析、深度學習、

機器學習

Literature Review

- 2018工業工程展專題
  - 長晶製程參數智能化解析──斷線率改善與控制
  - 迴歸分析參數數據(Minitab)

- 2019工業工程展專題
  - 半導體長晶製程斷線之檢測與改善
  - 迴歸分析參數數據(R)
  - 卷積類神經網路分析影像資料(CNN)

- 2019智慧化企業整合
  - 類神經網路分析參數數據(NN)

02

Machine Learning model

- Data-preprocessing
- Model architecture

Data-preprocessing

資料取得

晶圓廠非公開資料

長晶爐控制機台輸出

資料混和

98%斷線發生在晶身

非斷線：斷線 = 3:1

非斷線=0；斷線=1

取晶身長度至55公分

關鍵少數

可控參數

目標拉速、目標晶棒直徑、實際晶轉、實際堝升比、實際氬氣流量、上下爐腔爐壓

差分

計算參數變化量

$f(t)=f(t)-f(t-1)$

Model architecture

- 類神經網路NN

```
from keras.models import Sequential
from keras.layers import Dense

classifier = Sequential()

classifier.add(Dense(input_dim = d, output_dim = 32 , init = 'uniform', activation = 'relu'))

classifier.add(Dense(output_dim = 16, init = 'uniform', activation = 'relu'))

classifier.add(Dense(output_dim = 1, init = 'uniform', activation = 'relu'))

classifier.compile(optimizer = 'adam', loss = 'binary_crossentropy', metrics = ['accuracy'])

classifier.fit(train_set, y_train, batch_size=50, nb_epoch=50, validation_split = 0.1)
```

Accuracy
85%

03

Analysis

- Training process
- Training summary

Training process

- Optimizer

```
classifier = Sequential()

classifier.add(Dense(input_dim = d, output_dim = 32 , init = 'uniform', activation = 'relu'))

classifier.add(Dense(output_dim = 16, init = 'uniform', activation = 'relu'))

classifier.add(Dense(output_dim = 1, init = 'uniform', activation = 'relu'))

classifier.compile(optimizer = 'Nadam', loss = 'binary_crossentropy', metrics = ['accuracy'])

classifier.fit(train_set, y_train, batch_size=50, nb_epoch=50, validation_split = 0.1)
```

Accuracy
86%

- Activation function

```
classifier = Sequential()

classifier.add(Dense(input_dim = d, output_dim = 32 , init = 'uniform', activation = 'relu'))

classifier.add(Dense(output_dim = 16, init = 'uniform', activation = 'sigmoid'))

classifier.add(Dense(output_dim = 1, init = 'uniform', activation = 'sigmoid'))

classifier.compile(optimizer = 'Nadam', loss = 'binary_crossentropy', metrics = ['accuracy'])

classifier.fit(train_set, y_train, batch_size=50, nb_epoch=50, validation_split = 0.1)
```

Accuracy
90%

Training process

- Layers

```
classifier = Sequential()

classifier.add(Dense(input_dim = d, output_dim = 32 , init = 'uniform', activation = 'relu'))

classifier.add(Dense(output_dim = 16, init = 'uniform', activation = 'sigmoid'))

classifier.add(Dense(output_dim = 16, init = 'uniform', activation = 'sigmoid'))

classifier.add(Dense(output_dim = 1, init = 'uniform', activation = 'sigmoid'))

classifier.compile(optimizer = 'Nadam', loss = 'binary_crossentropy', metrics = ['accuracy'])

classifier.fit(train_set, y_train, batch_size=50, nb_epoch=50, validation_split = 0.1)
```

Accuracy
91%

- Neurons

```
classifier = Sequential()

classifier.add(Dense(input_dim = d, output_dim = 512 , init = 'uniform', activation = 'relu'))

classifier.add(Dense(output_dim = 256, init = 'uniform', activation = 'sigmoid'))

classifier.add(Dense(output_dim = 256, init = 'uniform', activation = 'sigmoid'))

classifier.add(Dense(output_dim = 1, init = 'uniform', activation = 'sigmoid'))

classifier.compile(optimizer = 'Nadam', loss = 'binary_crossentropy', metrics = ['accuracy'])

classifier.fit(train_set, y_train, batch_size=50, nb_epoch=50, validation_split = 0.1)
```

Accuracy
93%

Training summary

Model	Optimizer	Activation function	Layers	Neurons	Accuracy
1	adam	relu	3	32,16,1	85
2	Nadam	sigmoid	3	32,16,1	86
3	Nadam	sigmoid	4	32,16,16,1	90
4	Nadam	sigmoid	4	512,256,256,1	**93**

04

Discussion

- Conclusion

Conclusion

改善斷線率

- 參數調整邏輯改善
- 準確度93%

實務驗證

- 實驗設計
- 即時監控

模型改善

- 資料擴充、處理
- 機器學習、深度學習

Thanks.

長晶製程參數智能化解析——斷線率改善與控制

智慧化企業整合 Intelligent Integration of Enterprise
108034541 周郁淇