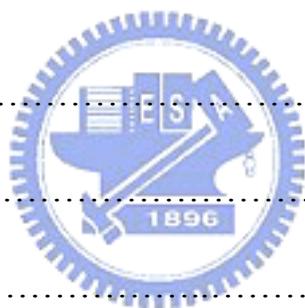


# 目錄

英文摘要.....	i
中文摘要.....	ii
誌謝.....	iii
目錄.....	iv
圖目錄.....	viii
表目錄.....	xii



一、緒論.....	1
1-1 半導體封裝簡介.....	1
1-2 環氧樹脂簡介.....	5
1-2-1 環氧樹脂之介紹.....	5
1-2-2 環氧樹脂之特性.....	6
1-2-3 環氧樹脂之硬化.....	7
1-2-4 環氧樹脂與胺類硬化劑.....	9
1-3 聚亞醯胺簡介.....	11
1-4 砂氧烷簡介.....	14
1-5 含砂氧烷之亞醯胺或環氧樹脂相互間補強材料.....	16
1-5-1 含亞醯胺基環氧樹脂相關文獻.....	16

1-5-2 含矽氧烷聚亞醯胺相關文獻.....	19
1-5-3 含矽氧烷環氧樹脂相關文獻.....	21
<b>1-6 氰酸酯簡介.....</b>	<b>23</b>
1-6-1 氰酸酯介紹.....	23
1-6-2 氰酸酯合成原理.....	24
1-6-3 氰酸酯與環氧樹脂之反應機構.....	25
<b>1-7 研究動機.....</b>	<b>27</b>
<b>二、實驗.....</b>	<b>28</b>
2-1 藥品與材料.....	28
2-1-1 藥品與材料.....	28
2-1-2 試藥純化.....	29
2-2 環氧樹脂系統.....	30
2-3 儀器與設備.....	31
2-4 單體合成.....	33
2-5 環氧化當量滴定.....	42
2-6 合成化合物鑑定.....	44
2-6-1 $^1\text{H}$ 核磁共振光譜.....	44
2-6-2 $^{13}\text{C}$ 核磁共振光譜.....	44
2-6-3 紅外線光譜分析.....	44

2-7 交聯行為分析.....	45
2-7-1 硬化反應配方.....	45
2-7-2 動態 DSC 分析.....	45
2-7-3 交聯過程之 FT-IR 分析.....	46
2-7-4 交聯樣品製作.....	46
2-8 交聯後材料性質測試.....	47
2-8-1 热膨胀系数測試 (TMA) .....	47
2-8-2 热重量分析儀分析 (TGA) .....	47
2-8-3 凝膠分率測試 (Gel fraction) .....	47
2-8-4 介電常數測試.....	48
三、結果與討論.....	49
3-1 合成流程.....	49
3-2 單體之鑑定.....	51
3-2-1 5,5-(1,1,3,3-tetramethyl-1,1,3,3-disiloxanodialyl)-bis-norbornane - 2,3-dicarboxylic anhydride.....	51
3-2-2 4-(4-hydroxyphenyl)-8-[1-({1-[4-(4-hydroxyphenyl)-3,5-dioxo- 4-azatricyclo[5,2,1,0 <sup>2,6</sup> ]dec-8-yl]-1,1-dimethylsilyl}oxy)-1,1- dimethylsilyl]-4-azatricyclo[5,2,1,0 <sup>2,6</sup> ]decane-3,5-dione.....	52
3-2-3 4-[4-(allyloxy)phenyl]-8-{1-[(1-{4-[4-(allyloxy)phenyl]-3,5- dioxo-4-azatricyclo[5,2,1,0 <sup>2,6</sup> ]dec-8-yl}-1,1-dimethylsilyl)oxy]-1 ,1-di methylsilyl}-4-azatricyclo[5,2,1,0 <sup>2,6</sup> ]decane-3,5-dione....	53

3-2-4 4-(3-allyl-4hydroxyphenyl)-8-[1-(1-[4-(3-allyl-4hydroxyphenyl) -3,5-dioxo-4-azatricyclo[5,2,1,0 <sup>2,6</sup> ]dec-8-yl]-1,1-dimethylsilyl} oxy)-1,1-dimethylsilyl]-4-azatricyclo[5,2,1,0 <sup>2,6</sup> ]decane-3,5-dion e.....	54
3-2-5 N,N'-bis(3-allyl-4-cyanatophenyl)-5,5'-(1,1,3,3-tetramethyl- 1,1,3,3-disiloxanodialyl)-bis-norbornane-2,3-dicarboximide...56	
3-3 交聯行為討論.....	58
3-3-1 動態 DSC 分析.....	58
3-3-2 硬化條件.....	61
3-3-3 硬化過程之紅外線光譜分析.....	62
3-4 交聯產物性質測試.....	64
3-4-1 凝膠分率測試.....	64
3-4-2 热膨胀係數分析.....	65
3-4-3 热重機械分析.....	66
3-4-4 介電常數測試.....	68
四、結論.....	69
五、參考文獻.....	71

## 圖 目 錄

Figure 1-1 Industrial structure of semiconductor.....	1
Figure 1-2 The revenue of global packaging market.....	2
Figure 1-3 IC package and Material properties.....	3
Figure 1-4 Chemical structure of Bisphenol A.....	6
Figure 1-5 Curing reaction of three curing agent.....	8
Figure 1-6 Reaction mechanism between epoxy monomer and cyanate ester resin.....	25
Figure 3-1 $^1\text{H}$ NMR spectrum of compound I.....	75
Figure 3-2 $^{13}\text{C}$ NMR spectrum of compound I.....	76
Figure 3-3 FT-IR spectrum of compound I.....	77
Figure 3-4 MASS spectrum of compound I.....	78
Figure 3-5 $^1\text{H}$ NMR spectrum of compound II.....	79
Figure 3-6 $^{13}\text{C}$ NMR spectrum of compound II.....	80
Figure 3-7 FT-IR spectrum of compound II.....	81
Figure 3-8 MASS spectrum of compound II.....	82
Figure 3-9 $^1\text{H}$ NMR spectrum of compound III.....	83
Figure 3-10 $^{13}\text{C}$ NMR spectrum of compound III.....	84
Figure 3-11 FT-IR spectrum of compound III.....	85
Figure 3-12 MASS spectrum of compound III.....	86

Figure 3-13 $^1\text{H}$ NMR spectrum of compound IV.....	87
Figure 3-14 $^{13}\text{C}$ NMR spectrum of compound IV.....	88
Figure 3-15 FT-IR spectrum of compound IV.....	89
Figure 3-16 MASS spectrum of compound IV.....	90
Figure 3-17 Mechanism of Claisen rearrangement.....	55
Figure 3-18 $^1\text{H}$ NMR spectrum of compound V.....	91
Figure 3-19 $^{13}\text{C}$ NMR spectrum of compound V.....	92
Figure 3-20 FT-IR spectrum of compound V.....	93
Figure 3-21 MASS spectrum of compound V.....	94
Figure 3-22 Dynamic DSC of sample (GA-240/V) , A=100/0 , B=70/30 , C=60/40 , D=50/50 , E=40/60 , F=0/100.....	95
Figure 3-23 Dynamic DSC of sample (GA-240/V=100/0) with different rise temp rate.....	96
Figure 3-24 Dynamic DSC of sample (GA-240/V=70/30) with different rise temp rate.....	97
Figure 3-25 Dynamic DSC of sample (GA-240/V=60/40) with different rise temp rate.....	98
Figure 3-26 Dynamic DSC of sample (GA-240/V=50/50) with different rise temp rate.....	99
Figure 3-27 Dynamic DSC of sample (GA-240/V=40/60) with different rise temp rate.....	100
Figure 3-28 $\ln(\Phi/\text{T}_m^2)$ VS $1/\text{T}_m$ of sample (GA-240/V=100/0).....	101

Figure 3-29 $\ln(\Phi/T_m^2)$ VS $1/T_m$ of sample (GA-240/V=70/30).....	102
Figure 3-30 $\ln(\Phi/T_m^2)$ VS $1/T_m$ of sample (GA-240/V=60/40).....	103
Figure 3-31 $\ln(\Phi/T_m^2)$ VS $1/T_m$ of sample (GA-240/V=50/50).....	104
Figure 3-32 $\ln(\Phi/T_m^2)$ VS $1/T_m$ of sample (GA-240/V=40/60).....	105
Figure 3-33 FT-IR spectra of sample (GA-240/V=50/50) cured at 130°C	
for different curing times ( $A_t$ , t in minutes) in the range of $600-4000\text{ cm}^{-1}$ .....	106
Figure 3-34 FT-IR spectra of sample (GA-240/V=50/50) cured at 130°C	
for different curing times ( $A_t$ , t in minutes) in the range of $600-2400\text{ cm}^{-1}$ .....	107
Figure 3-35 FT-IR spectra of sample (GA-240/V=50/50) cured at 130°C	
for different curing times ( $A_t$ , t in minutes) in the range of $2100-2500\text{ cm}^{-1}$ .....	108
Figure 3-36 FT-IR spectra of sample (GA-240/V=50/50) cured at 130°C	
for different curing times ( $A_t$ , t in minutes) in the range of $1200-2000\text{ cm}^{-1}$ .....	109
Figure 3-37 FT-IR spectra of sample (GA-240/V=50/50) cured at 130°C	
for different curing times ( $A_t$ , t in minutes) in the range of $800-1200\text{ cm}^{-1}$ .....	110
Figure 3-38 Difference FT-IR spectra ( $A_t-A_0$ , t in minutes) of sample	
(GA-240/V=50/50) cured at 130°C .....	111

Figure 3-39 FT-IR spectra of sample (GA-240/V=50/50) cured at 190°C	
for different curing times ( $A_t$ , t in minutes) in the range of 600-4000 $\text{cm}^{-1}$ .....	112
Figure 3-40 FT-IR spectra of sample (GA-240/V=50/50) cured at 190°C	
for different curing times ( $A_t$ , t in minutes) in the range of 600-2400 $\text{cm}^{-1}$ .....	113
Figure 3-41 FT-IR spectra of sample (GA-240/V=50/50) cured at 190°C	
for different curing times ( $A_t$ , t in minutes) in the range of 2100-2500 $\text{cm}^{-1}$ .....	114
Figure 3-42 FT-IR spectra of sample (GA-240/V=50/50) cured at 190°C	
for different curing times ( $A_t$ , t in minutes) in the range of 1200-2000 $\text{cm}^{-1}$ .....	115
Figure 3-43 FT-IR spectra of sample (GA-240/V=50/50) cured at 190°C	
for different curing times ( $A_t$ , t in minutes) in the range of 800-1000 $\text{cm}^{-1}$ .....	116
Figure 3-44 Difference FT-IR spectra ( $A_t-A_0$ , t in minutes) of sample (GA-240/V=50/50) cured at 190°C .....	117
Figure 3-45 Thermomechanical analyses of samples (GA-240/V) , B=70/30 , C=60/40 , D=50/50 , E=40/60.....	118
Figure 3-46 Thermogravimetric analyses of samples (GA-240/V) , A=100/0 , B=70/30 , C=60/40 , D=50/50 , E=40/60 , F=0/100.....	119

## 表 目 錄

Table 3-1 The maximum exothermic temp. of samples.....	58
Table 3-2 Dynamic DSC data of samples.....	60
Table 3-3 Curing condition of samples.....	61
Table 3-4 Gel fraction results of samples.....	64
Table 3-5 Thermal expansion coefficient of samples.....	65
Table 3-6 Thermogravimetric analysis of samples.....	67
Table 3-7 Dielectric constant and Loss factor of samples.....	68

