複晶矽薄膜電晶體之晶粒控制技術發展與

缺陷增強高電場效應分析

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摘　要

本論文分為二個部份，第一部份，我們研究一種晶粒控制技術:熱滯留增強結晶。利用熱儲存層，吸收雷射能量，持續提供熱能於矽膜，並減緩散熱，使晶粒得以控制於熱儲存膜處，並增大晶粒尺寸。第二部份，我們研究了晶粒影響之高電場效應。

首先，我們提出一個新的儲熱材料，可利用於熱滯留增強晶粒成長技術。此新穎的儲熱材料為”類鑽碳”(DLC)，類鑽碳在各個波段中顯現出非常好的光學吸收性，故類鑽碳可利用於現今雷射機台例如：較短波長的準分子雷射(308nm)與長波長的固態雷射(532nm)，做為儲熱材料。

本實驗中，我們成功地利用了 XeF 準分子雷射搭配類鑽碳熱儲存膜，控制橫向晶粒的成長位置，且晶粒尺寸可達 1 毫米。此外此晶粒的結晶品質可由拉曼分析參數如：峰值位置與半高寬，分別可達 516.25cm^{-1}與 4.9 cm^{-1}，是良好的結晶品質。

第二部份中，我們研究多晶矽薄膜電晶體元件受晶粒影響之高電場效應:扭結效應(Kink Effect)。由於扭結效應主要受雪崩效應(Avalanche Multiplication)引

起，故我們萃取累增因子(Multiplication Factor)為扭結效應之指標。發現累增因子在多晶矽中被晶粒影響的主要因素有二：(1)晶粒邊界位障、(2)晶粒尺寸。當晶粒邊界位障變大時，由於位障所產生的局部高電場隨之變大，使累增因子也變大。當晶粒尺寸變大時，可減緩位障所產生的局部高電場，故累增因子隨之變小。

另外，當雷射能量上昇時，多晶矽膜中晶粒邊界位障變小且晶粒尺寸變大，故加大雷射能量可在此二方面使累增因子減小。最後，我們發現固態晶體雷射之扭結效應較準分子雷射輕微。由於準分子雷射結晶之多晶矽膜具有較高的晶粒邊界位障，這更加佐証了前述的理論。也就是：晶粒邊界位障會增強高電場雪崩效應。

Study of Grain Control Technology and the Grain Boundary Trap-Enhanced Kink Effect in Poly-Si TFTs

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Abstract

This thesis divided into two parts. First, we studied the grain control technology: heat retaining enhanced crystallization (H-REC). The heat retaining layer absorbs the laser energy and keeps providing heat to amorphous silicon film. Also the heat retaining layer slows down the heat dispersion. This heat retaining enhanced crystallization technology makes it possible to control the position of grain growth and enlarging the grain size, too.

First, we proposed a new heat retaining material of the heat retaining enhanced crystallization. The novel heat retaining material: “diamond like carbon” (DLC). It shows great optical absorbance over a wide wavelength. Therefore, DLC can be used in the laser instrument nowadays, such as the shorter wavelength laser: excimer laser (308nm) and the longer wavelength laser: solid state laser (532nm).

In out experiment, we successfully controlled the position of lateral growth grain crystallized by XeF laser (351nm) and the heat retaining material: DLC. The maximum grain size can achieve 1um. Moreover the crystallinity can be realized by the Raman characteristics for instance, the Raman peak position and full width at half

maximum (FWHM) are 516.25cm^{-1} and 4.9cm^{-1} respectively. These reveal great qualities of crystallized film.

Second, we studied in the grain affected high electric field effect in polysilicon thin film transistors: “Kink Effect”. Kink effect mainly caused by the avalanche multiplication in depletion region near the drain. So we take the multiplication factor as a reference parameter to represent the influence of kink effect. It is found that the multiplication factor is mainly affected by two factors: (i) grain boundary barrier height (E_B) and (ii) grain size (L_G). When the grain boundary barrier height increases, the local high electric field caused by grain boundary barrier is enlarged and the multiplication factor becomes larger. Moreover, when the grain size increases, the local high electric field is reduced and the multiplication factor is also becomes smaller. Increasing the laser energy can suppress the kink effect in both manners: (i) the grain boundary barrier height is reduced and (ii) the grain size is enlarged.

Finally, we found that kink effect is less serious in solid state laser devices than in excimer laser devices. Since the polysilicon film crystallized by excimer laser has higher grain boundary barrier height than it crystallized by solid state laser. This also proves the proposed mechanism that: the grain boundary barrier height enlarges local electric field and enhances avalanche multiplication effect.