低介電常數材料與超臨界二氧化碳之可靠性分析與製程整合之研究

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摘要

本論文研究低介電常數材料 MSZ (Methylsilsesquiazane)薄膜與超臨界二氧化碳流體 (Supercritical CO_2 fluid)在積體電路製程整合的技術和可靠性分析。在傳統的多層導體連線微影製程中，去除光阻的步驟是無法避免的，而在去除光阻的過程中，氧電漿灰化是主要的製程方法，但此製程會造成低介電常數材料特性的劣化，且製程後必須使用化學溶劑去除電漿處理後的殘餘物，而這些化學溶劑不僅對人體和環境有害且需要使用大量水來處理這些溶劑。

超臨界二氧化碳流體被稱為綠色溶劑之一，具有像液體般密度高的特性，可傳送較氣體更多的超臨界流體；擴散係數遠比液體大，可具有快速傳輸的能力。此外，超臨界流體有如氣體幾無表面張力，因此很容易滲入到多孔性組織中。實驗中發現對於硬烤過的光阻，超臨界二氧化碳流體在適當條件下具有去除能力，且製程中僅需使用少量的溶劑。相對於氧電漿處理，本製程對低介電常數材料的影響較小，具有較小的介電常數和漏電流的改變，在可靠度上超臨界二氧化碳流體制程更是在電性上明顯優於氧電漿處理。

可預期地，超臨界二氧化碳流體的特殊特性將使其在積體電路製程整合中具有其優勢。

Investigation on Reliability and Process Integration of Low Dielectric Constant Materials and Supercritical Carbon dioxide

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Abstract

In this thesis, we will investigate on reliability and process integration of low dirlrctric constant material MSZ (Methylsilsesquiazane) and Supercritical CO_2 fluid. In the traditional lithography process for integrated circuit manufacture, photoresist removal step is an inevitable process. O_2 plasma ashing is the main method to remove the photoresist during photoresist stripping process. It was found that the oxygen plasma will degrade the dielectric properties of low-k material. After plasma ashing, the residues need to be stripped by solvents, and the solvents have adverse affects on humans and environment. Besides, they need to be removed by large amount of water.

Supercritical CO_2 fluid is one of the green solvents. It possesses the high density property like liquid, so it can transport more Supercritical fluid than liquid. And supercritical CO_2 has diffusivity greater than liquid, allowing for rapid transport properties. Besides, the absence of surface tension provides for excellent mass transport into micro-porous matrices. In the experiment, we confirm that hard-baked photoresist can be stripped by supercritical CO_2 fluid in the special condition, and it needs a small amount of solvents in the process. Comparing with oxygen plasma treatment, the process has little impact on MSZ film, and has little change in the dielectric constant and leakage current. On the reliability, the electrical properties of supercritical CO_2 fluid process are better than that of O_2 plasma ashing process.

With the excellent characteristic, supercritical CO_2 fluid will has the advantage to integrate into the IC manufacturing processes.

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