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Surface characterization of excimer laser induced deposition of W on GaAs from WF_6 and H_2

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Abstract

Deposition of W thin films has been induced by a KrF excimer laser incident perpendicularly on a GaAs substrate placed in an ambient containing WF_6, H_2 and Ar. In-situ X-Ray Photoelectron Spectroscopy (XPS) shows evidence of a surface interaction between WF_6 and GaAs under laser irradiation. At 50 mJ/cm^2, fluorinated W species adsorbed on the GaAs substrate are partially dissociated by the laser beam, leading to a loss in stoichiometry and the formation of GaF_3 on the surface. The generation of stable, non-volatile, GaF_3 has been identified as a possible obstacle to the nucleation of metallic tungsten films on GaAs in CVD processes using WF_6. At 67 mJ/cm^2, the gas-substrate interaction is further enhanced, but the dissociation of WF_6 into metallic W is achieved. However, at such laser energy densities, the substrate appears to be damaged. By using H_2 as a reducing gas for WF_6, 0.2 μm thick W deposits were obtained but the process was difficult to reproduce. Two competing phenomena, the fluorination of the GaAs surface and the nucleation of the metallic W films taking place simultaneously explain the difficulty in controlling the process. The Auger profiles show limited, but noticeable, As incorporation in the films resulting from the interaction between WF_6 and GaAs under laser irradiation.

1. Introduction

Tungsten is a low resistivity, refractory metal which has proved to be the most suitable material for self-aligned gates in the fabrication of GaAs MESFETs [1,2]. In such a process, the gate is used as a mask during ion implantation and must withstand high temperature anneals without suffering physical or electrical degradation. Tungsten [3], its silicides [4] and its nitrides [5] form Schottky contacts to GaAs which are thermally stable up to temperatures of the order of 850°C, while preserving a sharp metal/semiconductor interface and a low contact resistance [6]. Such materials can be deposited using physical vapor deposition (PVD) techniques such as e-beam evaporation [7], rf and magnetron sputtering [8,9]. However, these techniques can induce severe damage to the fragile GaAs substrate, due to the energetic electrons and ions present during the process. Therefore, the use of chemical vapor deposition (CVD) to deposit W metallic films seems to be a more appropriate approach. In most W CVD pro-

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