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Laser processing of tungsten from WF_6 and SiH_4

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Abstract

Low temperature laser processing of W using WF_6 and SiH_4 is discussed. This process can be applied with limited thermal budget to various substrates, giving the possibility of depositing thin films on fragile substrates like polyimide or GaAs. In a direct writing mode, an Ar^+ laser and a diode laser have been used to produce WSi_x with various controlled line profiles on polyimide and TiN. Best resistivities are between 40 and 80 $\mu\Omega \cdot cm$ and the composition W/Si vary from 1.4 to 1.8. Excimer laser induced deposition of W on GaAs for making Schottky contacts has also been investigated. This process yields pure α-W deposits with resistivities of 20 $\mu\Omega \cdot cm$.

1. Introduction

Laser beams directed onto a surface can be used to induce thin film deposition by either pyrolytic or photolytic chemical reactions in the gas phase or on the substrate [1]. In a pyrolytic laser chemical vapor deposition (LCVD) process, lasers are used as the heat source to induce a localized thermal reaction where the beam is focused on the substrate. The displacement of the beam on the surface leads to the direct 'writing' of patterns. However, UV photons may induce both pyrolytic and photolytic chemical reactions, either in the gas phase or on the surface. Projecting the UV photons from an excimer laser through a mask can lead to thin film deposition with high resolution patterns.

Tungsten is particularly interesting in microelectronics because it is a low resistivity refractory metal ($\rho_{bulk} = 5.6$ $\mu\Omega \cdot cm$). It can be used as a thermally stable interconnect material and it forms good Schottky contacts on GaAs. Laser processing using $W(CO)_6$ has been extensively studied [2–8], but growth rates are relatively low and the resistivity of the deposits is usually high (~ 200 ρ_{bulk}), owing to C and O incorporation in the films. In contrast, the use of WF_6 as the precursor usually leads to high purity thin films with low resistivity (~ 2 ρ_{bulk}) at relatively high growth rates. Tungsten has been deposited from WF_6 using excimer [9–13], CO_2 [14,15] and ion (Ar^+ and Kr^+) [16–28] lasers. Most of these studies relied on the reduction of WF_6 by hydrogen or by silicon substrates. However, hydrogen reduction of WF_6 occurs at relatively high temperature ($> 400°C$), and Si reduction, which takes place at lower temperatures, is self-limited to very thin films [22].

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