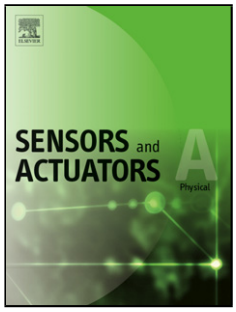

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Avoiding blister defects in low-stress hydrogenated amorphous silicon films for MEMS sensors

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Abstract

Low-stress silicon-based thin films play a crucial role in microelectromechanical systems (MEMS) such as silicon microphones. To obtain low stress, post annealing is usually applied and, in particular, the residual stress of hydrogenated amorphous silicon (α-Si:H) can be finely tuned by properly adjusting the annealing temperature to obtain slightly tensile thin films. However, blister defects are unfortunately observed in the course of stress control by high temperature annealing. We study structural parameters of thin films that may induce blistering behaviors and propose a statistical prediction model as a guide to avoid the blistering disaster for MEMS chips. By optimizing the shape, size, and thickness of thin films, the non-blister α-Si:H thin film with low stress of around 63 MPa is demonstrated.

Keywords: blister defect, stress control, hydrogenated amorphous silicon thin film, MEMS, annealing

1. Introduction

Thin-film materials such as hydrogenated amorphous silicon (α-Si:H) have been widely used in semiconductor devices, energy applications, and MEMS sensors. Specifically, α-Si:H films are often used as structural thin films in optical pixel sensor [1], organic photodiodes for image sensing [2], active-matrix liquid crystal display (AMLCD) applications [3], structural color filters [4], particle detectors [5] and solar cells [6]. Also, amorphous silicon is commonly used as the sacrificial layers in the surface micromachining of MEMS devices [7]. Moreover, crystallization of doped α-Si:H by annealing can produce large-grained polycrystalline silicon, which usually acts as the flexible membrane or cantilever beam embedded in plenty of MEMS applications, such as silicon microphones, capacitive micromachined ultrasonic transducers (cMUTs), piezoresistive MEMS pressure sensors, MEMS accelerometers and so on.

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