

Free-Standing Pd-Based Metallic Glass Membranes for MEMS Applications

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Abstract : Metallic glasses, which are free of grain boundaries, have superior properties including large elastic limits, high strength, and excellent wear and corrosion resistance. Therefore, bulk metallic glasses (BMG) and thin film metallic glasses (TFMG) have been widely developed and investigated. Among various kinds of metallic glasses, Pd-Cu-Si TFMG, which has lower elastic modulus and better resistance of oxidation and corrosions compared to Zr- and Fe-based TFMGs, can be a promising candidate for MEMS applications. However, the study of Pd-TFMG membrane is still limited. This paper presents free-standing Pd-based metallic glass membranes with large area fabricated on wafer level for the first time. Properties of Pd-Cu-Si thin film metallic glass (TFMG) with various deposition parameters are investigated first. When deposited at 25°C, compressive stress occurs in the Pd₇₆Cu₆Si₁₈ thin film regardless of Ar pressure. When substrate temperature is increased to 275°C, the stress state changes from compressive to tensile. Thin film stresses are slightly decreased when Ar pressure is higher. To show the influence of temperature on Pd-TFMGs, thin films without and with post annealing below (275°C) and within (370°C) supercooled liquid region are investigated. Results of XRD and TEM analysis indicate that Pd-TFMGs remain amorphous structure with well-controlled parameters. After verification of amorphous structure of the Pd-TFMGs, free-standing Pd-Cu-Si membranes were fabricated by depositing Pd-Cu-Si thin films directly on 200nm-thick silicon nitride membranes, followed by post annealing and dry etching of silicon nitride layer. Post annealing before SiN_x removal is used to further release internal stress of Pd-TFMGs. The edge length of the square membrane ranges from 5 to 8mm. The effect of post annealing on Pd-Cu-Si membranes are discussed as well. With annealing at 370°C for 5 min, Pd-MG membranes are fully distortion-free after removal of SiN_x layer. Results show that, by introducing annealing process, the stress-relief, distortion-free Pd-TFMG membranes with large area can be a promising candidate for sensing applications such as pressure and gas sensors.

Keywords : amorphous alloy, annealing, metallic glasses, TFMG membrane

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