Material Design of High Strength Electroplated Gold Alloy toward High-Sensitive MEMS Accelerometers

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Recently, Yamane et al. reported that the sensitivity of micro-electro-mechanical systems (MEMS) inertial sensors can be improved by replacing the conventional silicon-based components to gold-based materials [Appl. Phys. Lett. 104 (2014) 074102]. The high sensitivity is mostly contributed by the high density of gold (19.30 g/cm^3), which is much higher than that of silicon (2.33 g/cm^3). However, mechanical strengths of gold are relatively low (i.e., yield strength of bulk gold: 50-200 MPa [Acta Mater. 53 (2005) 1821]) when compared with other metallic materials, which has been a concern in practical applications as the movable components in MEMS. Grain boundary strengthening mechanism is a typical method available to enhance the mechanical strength of metallic materials based on the Hall-Petch relationship. As the grain size reaches submicron- or nano-scale, high strength can be obtained when compared to coarse-grained metals with the same chemical composition and phase constitution. Also alloying of metals can realize stronger mechanical strength than the pure metals. Electrodeposition is often applied in fabrication of the electronic components because of the near-room-temperature operating environment, low-energy requirements, controllable deposition rates, low cost and simple scale-up with easily maintained equipment. In order to realize high strength gold materials for applications in high-sensitive MEMS accelerometer, we have studied various electrodepositions of gold-alloy including constant current and pulse-plating methods and obtained gold-copper alloy with strength higher than 1.1GPa, which is 5 times higher than bulk gold.

Keywords: , MEMS, micro-mechanical property, electroplating, grain refinement, gold, alloy

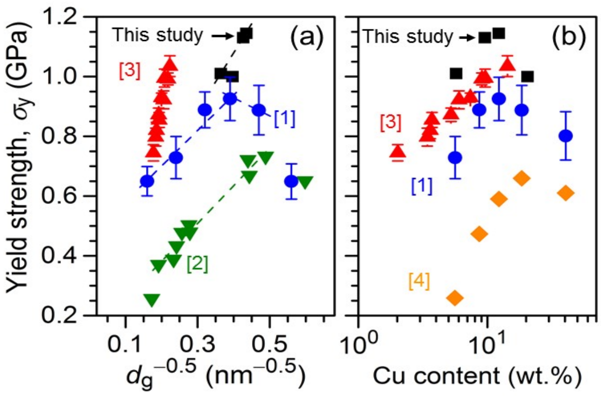

Fig. 1. Plots of (a) inverse-square root of the grain size versus the σ_y (H-P plot) and (b) log-scale of the Cu content versus the σ_y. [1]:E.Brun et al.(2011), [2] A. F. Jankowski et al.(2006), [3] J. Lohmiller et al.(2010) [4] N. P. Fedot'Ev et al.,(1959)

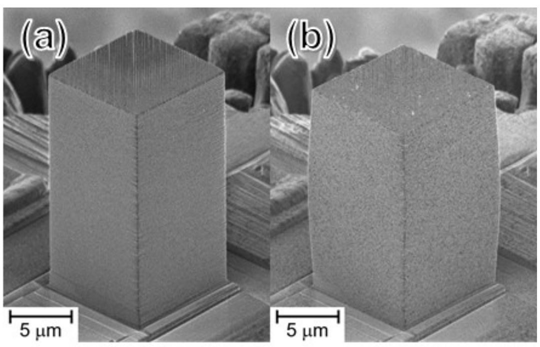

Fig. 2 SIM images of the Au-Cu alloy micro-pillars (a) before and (e) after the micro-compression tests.