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ABSTRACT

DESIGN, FABRICATION AND PERFORMANCE ANALYSIS OF ADVANCED MICROCONTACTS FOR MEMS SWITCHES

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Microelectromechanical systems (MEMS) contact switches are promising for many wireless communication applications because of their ability to provide low contact resistance and very low power consumption. Because of the physical contact in ohmic contact MEMS switches, the performance of these MEMS switches critically relies on the microcontact materials, their reliability, and their ability to perform under every condition. In this dissertation, we modeled, designed, fabricated, and tested advanced microcontacts to improve MEMS switch reliability.

Engineered contact geometry fabricated using reactive ion etching, on-die resistive and capacitive circuitry, and a durable nickel structural layer were introduced in these advanced microcontact devices to study and improve the behavior of microcontacts and MEMS switches over an extended period. To perform the characterization and testing of advanced microcontacts, we developed an improved, automated microcontact test setup. This setup includes nano-positioning force sensor, piezoelectric actuator, and piezoelectric controller to test the devices with high cycle rates, high actuation, and high precision control.

We did our investigation using ruthenium oxide (RuO_2) and gold (Au) microcontact materials, and analyzed the effect of contact geometries, device architecture, polarities, contact forces, on-die circuitry, different switching (hot and cold) and different load (DC and AC) conditions on the microcontact. These tests were executed for over hundreds of millions of cycles, and the result provided us with understanding of different contact failure modes and contact reliability under various testing conditions. Collected contact resistance and contact lifecycle data gave us insightful details on the behavior of tested RuO_2/Au microcontact structures, which not only help to evaluate our fabricated advanced microcontacts and their effects, but also benefit future research to choose proper microcontacts for designing durable and dependable MEMS microswitches.