A Low Contact Resistance MEMS-Relay

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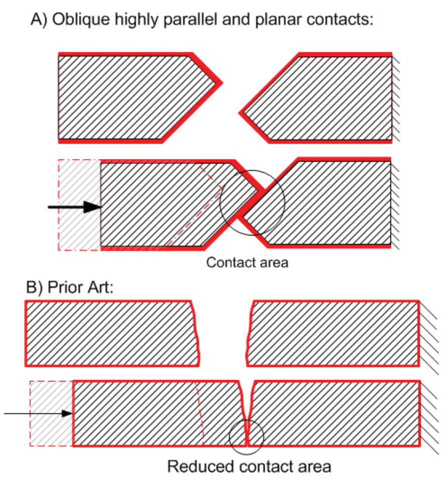
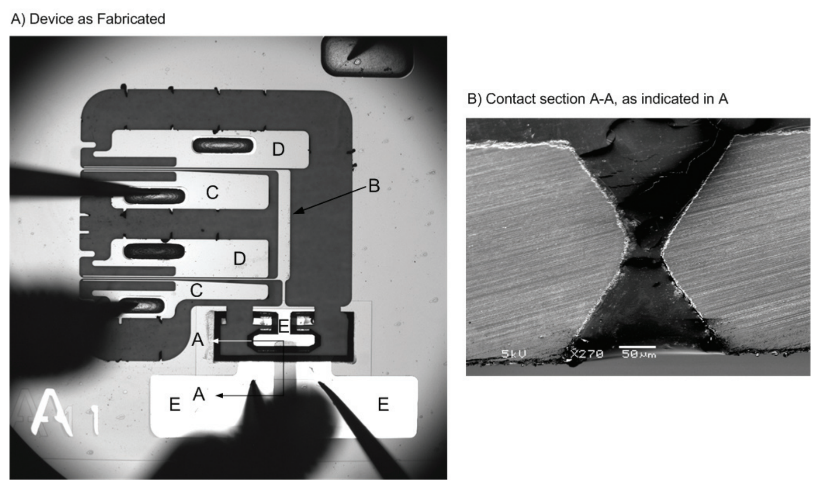
A low contact resistance MEMS-relay featuring highly parallel and planar oblique contacts has been fabricated and is currently being tested. The contacts are etched in silicon using a potassium hydroxide (KOH) solution. An offset between the wafer-top and the wafer-bottom KOH masks produces the oblique contact geometry schematically shown in Figure 1A.

In contrast, many prior art MEMS devices [1-3] have rough, non complementary contacts. As these surfaces touch, they do so in a small number of high points, as shown in Figure 1B, which significantly reduces the effective contact area and leads to a high contact resistance and a low current carrying capacity. Additionally, vertical contacts are prone to poor metallization, which further affects the device's contact resistance. Our MEMS-relay, shown in Figure 2, is composed of a compliant mechanism (B), a pair each of engaging (C) and disengaging (D) rolling-point "Zipper" actuators [4-5], and a pair of planar and parallel contacts (E).The relay is fabricated by a combination of deep reactive ion etching (DRIE) and KOH etching. Nested masks are used to pattern both wafer-through etches. Low stress silicon nitride (Si_3N_4), which will later be used as a KOH mask, is patterned initially on both sides of the device wafer. A silicon oxide film is deposited on the KOH mask. The compliant mechanism and actuators are then etched through DRIE and a second Si_3N_4 film is deposited. The second Si_3N_4 film is patterned using a "shadow" (through-etched) wafer as a mask. The oxide is selectively etched to reveal the buried nitride mask. The contacts are etched in KOH solution. Both Si_3N_4 and oxide films are stripped and a thermal oxide, which insulates both the electrostatic actuators and the relay contacts from the rest of the device, is grown. Gold is evaporated over both sides of the insulated contacts and the device wafer is anodically bonded to a Pyrex handle wafer. Experimental pull-in and drop-out voltages of 70 V and 40 V, respectively, agree with the model. Contact travel of 50 µm prevents arcing as the load circuit is switched on and off. A contact resistance of 50 mΩ was demonstrated by our group using an externally actuated structure as a proof of concept for the contact design [4]. Our group continues to develop these MEMS relays for power applications.



▲ Figure 1: Schematic cross section of oblique planar parallel contacts (A), schematic cross section of prior art (B).



▲ Figure 2: Device as fabricated (A), SEM contact cross section A-A of oblique contacts as shown in Figure 2A (B). The die saw causes the rough edge of the static contact in (B).

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