Bistable Micro Relays

Personnel

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Sponsorship

ABB

This project seeks to develop bistable MEMS relays that can carry currents up to several amperes when closed, stand off voltages up to several hundreds of volts when open, and switch between their closed and open states in milliseconds or less. Mechanical bistability is an important feature of these relays. It allows the relays to remain open or closed without continued excitation. Excitation is employed only to switch the relays from one state to the other.

Figure 1 shows the primary relay components. The relay comprises a flexible mechanically-bistable double beam [1] and two contacts. In its as-fabricated stable position (solid lines), the relay is open. The double beam has a second stable position (dashed lines) in which it could rest in the absence of the contacts. However, because the contacts are located between the two stable positions, the double beam actually comes to rest after deflection as a shorting bar across the two contacts, exerting a force to ensure low contact resistance.

To date, we have actuated the bistable double beams with both electric and electrothermal actuators. Figure 1 shows the case of electrothermal actuation. Selective metalization renders the outer beam of each actuator more conducting, and hence less lossy, than its inner beam. The resulting differential heating and expansion of the beams in response to electrical excitation produces a transient deflection of the actuators. Actuator #1 deflects downward pushing the double beam into its second stable position thereby closing the relay. Actuator #2 deflects upward pushing the double beam into its original stable position thereby opening the relay.

The relays are fabricated using a single deep-reactive ion etch through a silicon wafer. The resulting device wafer is bonded to an insulating handle wafer having pits above which the device wafer components may move. Metal is then sputtered onto the device wafer through a shadow mask to provide bonding pads, sidewall metalization and a resistance differential for the electrothermal actuators. Finally, breakoff tabs are removed to isolate the relay components.

Figures 37 and 38 show photographs of a relay in its as-fabricated open position and in its closed position, respectively. The relay employs an additional compliant spring to balance the contact forces when it closes. This local compliance ensures that fabrication variations in the double beam do not cause unbalanced contact forces. For reference, the double beam is 0.8 cm long, and its beams are 20 μm wide; the electrothermal actuators are 1.2 cm long, and their beams are 120 μm wide.

When the electrothermal actuators are excited by a 1.5-A 1-ms pulse, they push the double beam through a 230-μm deflection to open and close the relay. The double beam is believed to exert a 4-mN force on each contact. With this force, the contact resistance is typically 250 milliohms, and the contacts can carry up to 1.5 A without fusing. In its off-state, the relay can standoff in excess of 200 V.

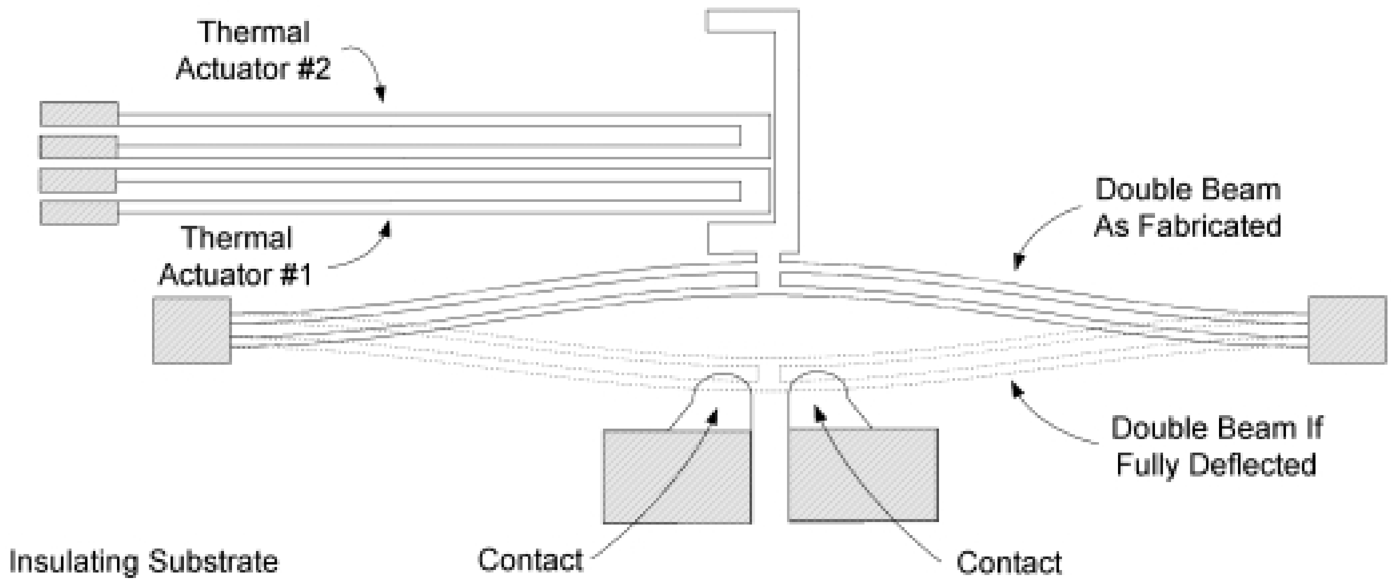

Fig. 37: the primary components of the relay; they are anchored to the substrate in their shaded regions.

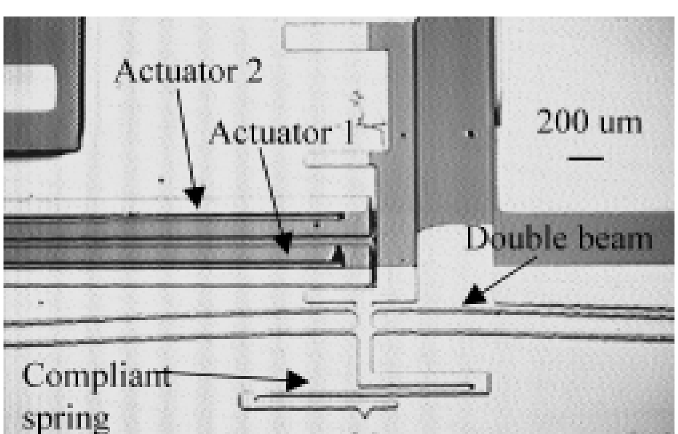

Fig. 38: photograph of a relay in its off position.

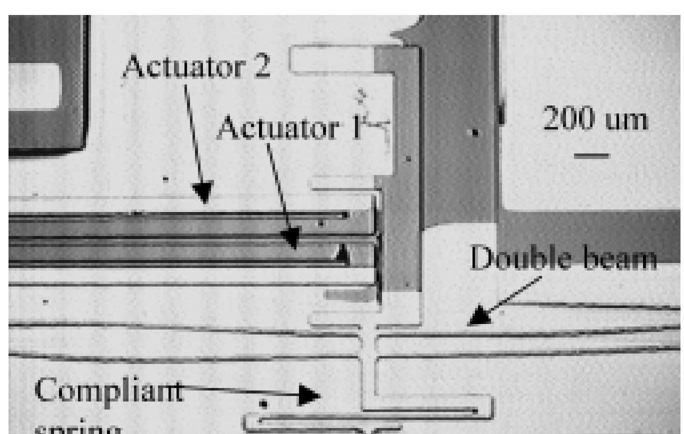

Fig. 39: photograph of a relay in its on position.