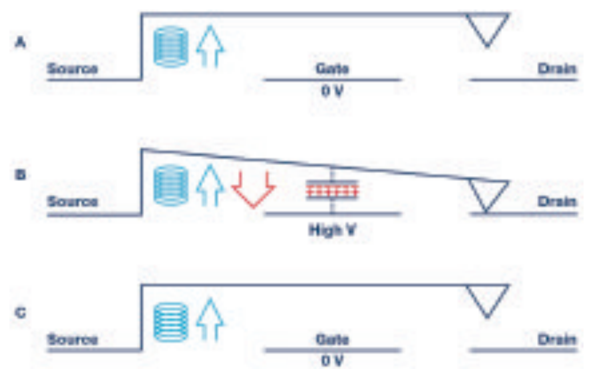

Figure 2. MEMS switch actuation process: A and C show the switch turned off; B shows it turned on

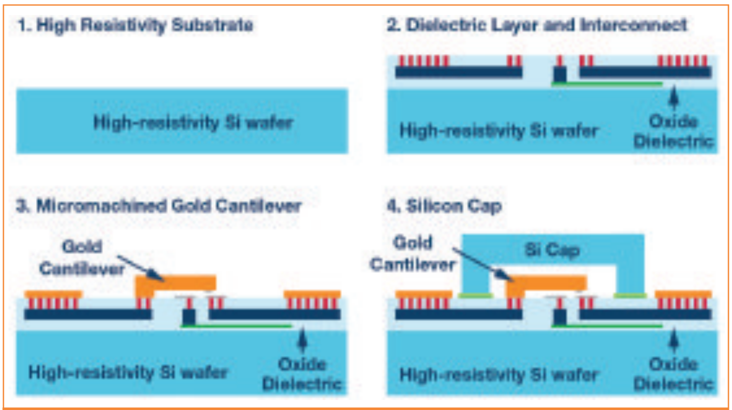

Figure 3. MEMS switch fabrication overview

would be seen in a parallel-plate capacitor, having positive and negative charged plates that attract each other. When the gate voltage ramps to a high enough value, it creates enough attraction force (red arrow) to overcome the resistive spring force of the switch beam, and the beam starts to move down until the contacts touch the drain.

This is shown in Case B in Figure 2. This completes the circuit between the source and the drain, meaning the switch is now on. The specific force it takes to pull the switch beam down is related to the spring constant of the cantilever beam and its resistance to movement. Notice that even in the 'on' position, the switch beam still has a spring force that pulls the switch up (blue arrow); but as long as the down-pulling electrostatic force (red arrow) is larger, the switch will remain on. Finally, when the gate voltage is removed (see Case C in Figure 2) – that is 0V on the gate electrode – then the electrostatic attraction force disappears, and the switch beam acts as a spring with sufficient restoring force (blue arrow) to open the connection between the source and the drain, and then, returns to the original 'off' position.

Figure 3 shows the four main steps in fabricating a switch using MEMS technology. The switch is constructed on a high-resistivity silicon wafer (1), which has a thick dielectric layer deposited on top to provide superior electrical isolation from the substrate below. A standard back-end CMOS interconnect process is used to realise interconnections to the MEMS switch. Low-resistivity metal and polysilicon are used to make an electrical connection to the MEMS switch, and are embedded into the dielectric layer (2). Metal vias marked in red (2) are used to provide a connection to the switch input, output, and the gate electrode to wire bond pads elsewhere on the die. The cantilever MEMS switch itself is surface-micromachined using a sacrificial layer to create the air gaps under the cantilever beam. The cantilever switch beam structure and bond pads (3) are formed using gold. Switch contact and gate electrodes are formed using a low-resistance thin metal, deposited on the surface of the dielectric.

Wire bond pads are also built using the above steps. Gold wire bonding is used to connect the MEMS die to a metal lead frame, encapsulated into a plastic QFN (quad-flat, no-lead) package for easy surface-mounting on PCBs. The die is not limited to any one type of packaging technology. This is due to the fact that a high-resistivity silicon cap (4) is bonded to the MEMS die to form a hermetic protective housing around the MEMS switch device. Hermetically enclosing the switch in this way increases the environmental robustness and cycle lifetime of the switch, regardless of what external package technology is used.

Figure 4 shows a zoomed-in graphic of four MEMS switches in a single-pole four-throw (ST4T) multiplexer configuration. Each switch beam has five ohmic contacts in parallel to reduce resistance and increase power handling when the switch is closed.

The MEMS switch requires a high DC drive voltage to electrostatically-actuate the switch. To make the part as easy to use as possible and further guarantee performance, a companion driver integrated circuit (IC) has been designed by – to generate high DC voltages – and co-packaged with the MEMS switch in a QFN form factor. In addition, the high-actuation voltage generated is applied to the gate electrode of the switch in a controlled manner. It is ramped up to a high voltage in microsecond timescales.

A key tenet to any new technology is of course how reliable it is, and ADI's new MEMS technology manufacturing process was the base that enabled the development of mechanically-robust, high-performance switch designs.

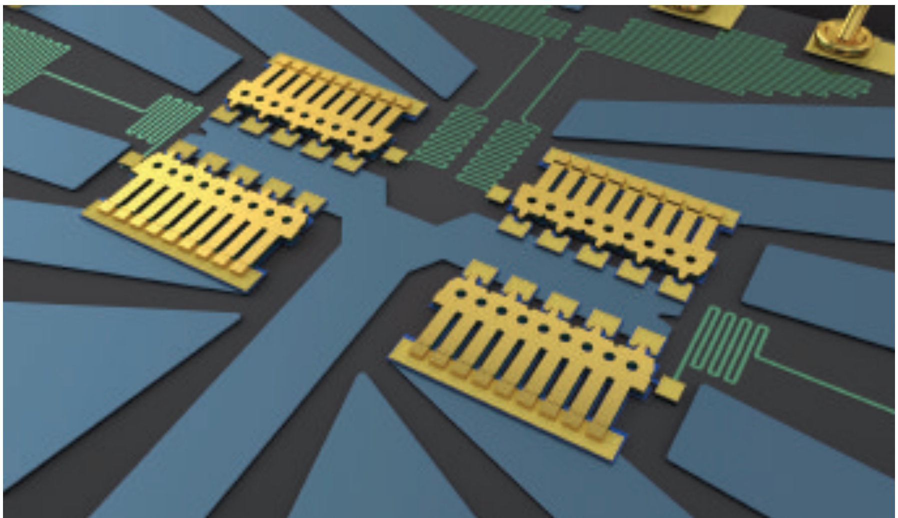

Figure 4. Close-up graphic showing four MEMS cantilever switch beams (SP4T configuration).