Supporting Information

Reconfigurable multiwavelength nanophotonic circuit based on low-voltage optically readable engineered resistive switch

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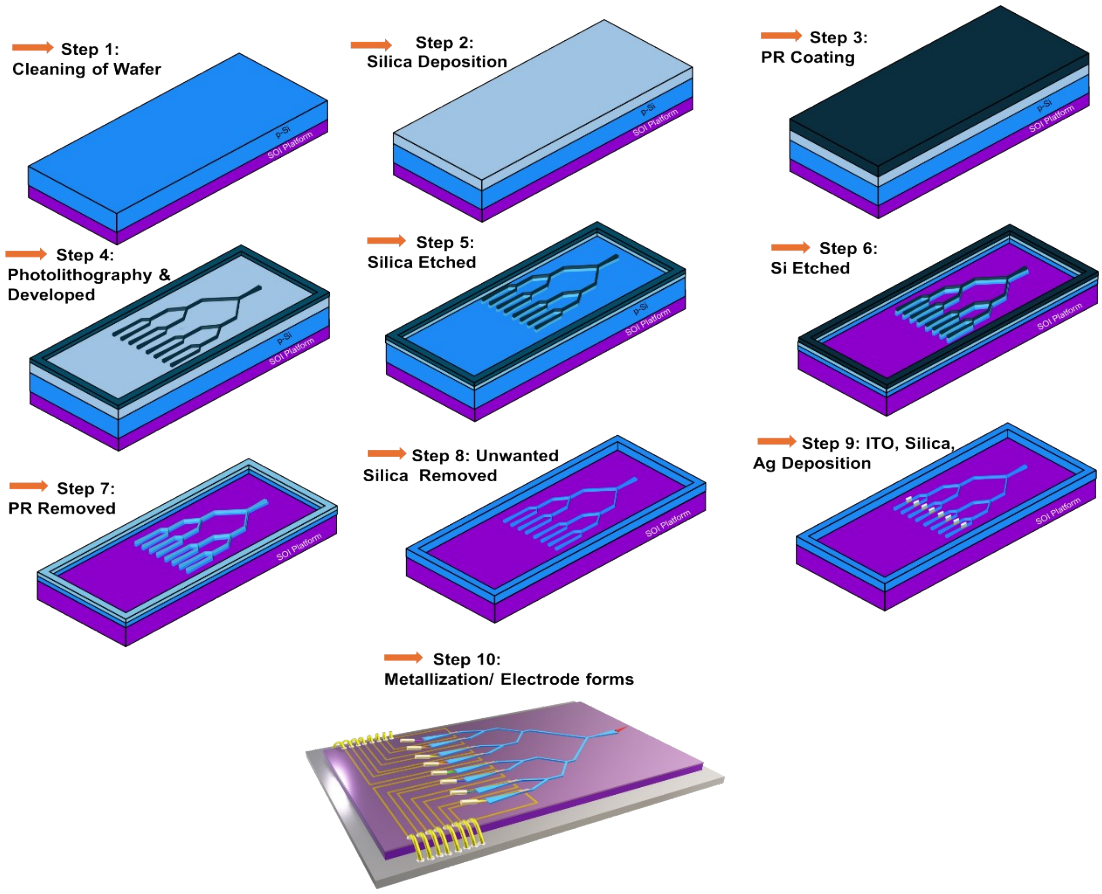
I. Reconfigurable Nanophotonic Circuit Fabrication

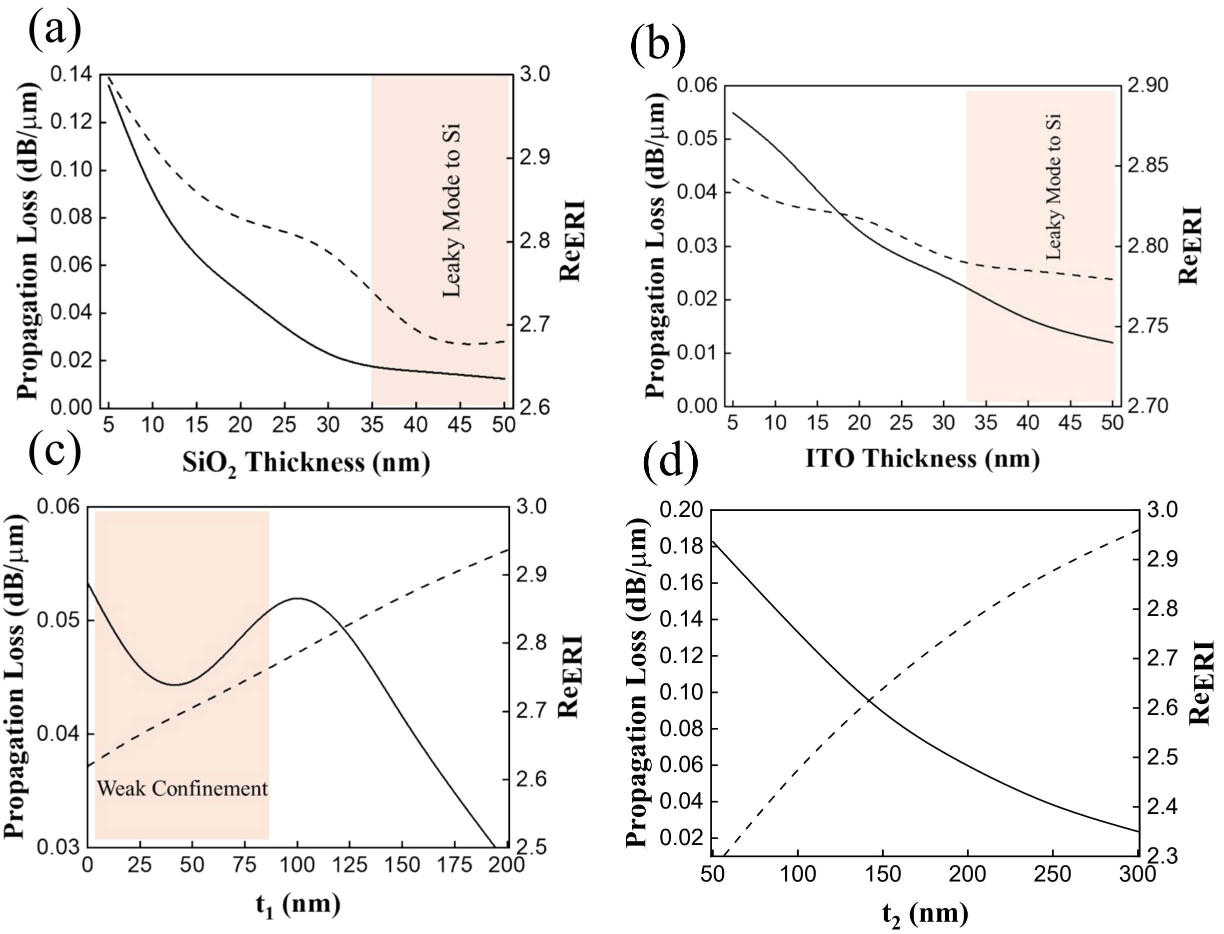


Supplementary Figure 1. 3D-schematic illustrates the standard CMOS-compatible fabrication process of the proposed reconfigurable multiwavelength nanophotonic circuit based on engineered resistive switch. The process involves sequential cleaning steps, thermal treatment of silica, photoresist coating, lithography patterning, wet etching of silicon and silica, removal of photoresist, deposition of ITO, and silica using RF sputtering, metal deposition via DC sputtering, and completion of metallization.

As illustrated in Fig. S1, a 3D schematic of the standard CMOS-compatible fabrication process of the proposed engineered reconfigurable multiwavelength nanophotonic circuit based on resistive switches on a SOI wafer. Initially, the wafer is cleaned sequentially with isopropyl alcohol (IPA), acetone, and deionized water. Initially, the wafer is cleaned sequentially with isopropyl alcohol (IPA), acetone, and deionized water. Subsequently, a 10 nm thin oxide layer was thermally grown using an oxidation furnace at 1000°C for 10 minutes to serve as a protective layer during the wet etching process of silicon. A positive photoresist, AZ-1505, was applied via spin coating at 6000 rpm for 45 seconds with an acceleration of 850 rpm/sec. This was followed by a prebake at 115°C for 1 minute on a hotplate. First layer maskless photolithography (Pico Mater 100) was employed to define the silicon waveguide and couplers. After exposure, the resist was manually developed by rinsing with AZ-1505 developer for 4 seconds. Silica and silicon etching was performed respectively, using a diluted HF solution and a 4:1 diluted tetramethylammonium hydroxide solution to create rib structure waveguide. Unwanted silica was subsequently removed using a diluted HF solution. A second layer lithography step was performed specifically for the engineered nanophotonic resistive switch, followed by development. Selective indium tin oxide (ITO) was deposited using RF sputtering at an argon gas flow rate of 40 sccm, with a sputtering power of 80 watts. A third layer lithography step was performed followed by development of PR specifically for the silica and Ag deposition over active region of nanophotonic circuits. Silica was selectively deposited under similar conditions but with a sputtering power of 110 watts. Silver (Ag) was deposited using DC sputtering at an argon gas flow rate of 30 sccm and a sputtering power of 60 watts. To remove unwanted layers of silica and Ag, samples were immersed in acetone and subjected to ultrasonication to eliminate residuals. Finally, metallization (followed by fifth layer lithography and development of PR) was performed for electrode formation is completed.

II: Numerically Optical Analysis of Nanophotonic Resistive Switch

Figure S2 illustrate the numerically optical analysis and optimization of the proposed engineered nanophotonic resistive switch. Figure S2a shows the variation of propagation loss (solid line) and the real part of the effective refractive index (Re_{ERI}) (dotted line) as a function of the SiO_2 thickness (t_{SiO2}), ranging from $5\ nm$ to $50\ nm$. The thicknesses of the metal and ITO layers are $200\ nm$ and $10\ nm$, respectively. The rib-shaped Si thicknesses (t_1 and t_2) are $120\ nm$ and $220\ nm$, respectively, and the width of the nanophotonic waveguide (w) is $500\ nm$. Both propagation loss and Re_{ERI} decrease as t_{SiO2} increases. However, increasing t_{SiO2} results in weaker confinement, causing the hybrid plasmonic mode to leak into the silicon. The optimal



Supplementary Figure 2. Numerically optical analysis of the proposed nanophotonic resistive switch. a. Variation of propagation loss and real part of effective refractive index (Re_{ERI}) vs SiO_2 thickness. b Variation of propagation loss and Re_{ERI} vs ITO thickness. c Variation of propagation loss and Re_{ERI} vs rib Si thickness (t_1). d Variation of propagation loss and Re_{ERI} vs rib Si thickness (t_2).

t_{SiO2} for achieving better hybrid plasmonic confinement and low propagation loss is $20\,nm$. Figure S2b depicts the variation of propagation loss (solid line) and Re_{ERI} (dotted line) as a function of the ITO thickness (t_{ITO}), ranging from 5 nm to 50 nm. The thicknesses of the metal and SiO_2 layers are $200\,nm$ and $10\,nm$, respectively. The rib-shaped Si thicknesses (t_1 and t_2) are $120\,nm$ and $220\,nm$, respectively, and the width of the nanophotonic waveguide (w) is $500\,nm$. Both propagation loss and Re_{ERI} decrease as t_{ITO} increases. However, increasing t_{ITO} results in weaker confinement, causing the hybrid plasmonic mode to leak into the silicon. The optimal t_{ITO} for achieving better hybrid plasmonic confinement and low propagation loss is $10\,nm$. Figure S2c shows the variation of propagation loss (solid line) and Re_{ERI} (dotted line) as a function of the rib-shaped structure thickness (t_1), ranging from $0\,nm$ to $200\,nm$. The thicknesses of the metal, SiO_2, and ITO layers are $200\,nm$, $20\,nm$, and $10\,nm$, respectively. The width of the nanophotonic waveguide (w) and t_2 are $500\,nm$ and $220\,nm$, respectively. Propagation loss decreases as t1 increases up to 40 nm, then increases until t_1 reaches $95\ nm$, and decreases again thereafter. Re_{ERI} increases as t1 increases. Increasing t_1 strengthens the confinement, causing the hybrid plasmonic mode to primarily confine in the SiO_2 region. The optimal t_1 for achieving better hybrid plasmonic confinement and low propagation loss is $120\ nm$. Figure S2d illustrates the variation of propagation loss (solid line) and Re_{ERI} (dotted line) as a function of the rib-shaped structure thickness (t2), ranging from 0 nm to 300 nm. The thicknesses of the metal, SiO_2, and ITO layers are $200\ nm$, $20\ nm$, and $10\ nm$, respectively. The width of the nanophotonic waveguide (w) and t_1 are $500\ nm$ and $120\ nm$, respectively. Propagation loss decreases, and Re_{ERI} increases as t_2 increases. The stronger confinement of the hybrid plasmonic mode is primarily observed in the SiO_2 region at $t_2 = 220\ nm$, resulting in better confinement and low propagation loss.