**A. Source Data**

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| Parent Figure or Table | Filename  Whole original file name including extension. i.e.: *Smith\_SourceData\_Fig1.xls,* or *Smith\_ Unmodified\_Gels\_Fig1.pdf* | Data description  i.e.: Unprocessed western Blots and/or gels, Statistical Source Data, etc. |
| Source Data Fig. 1 | TSEM\_1.tif,TSEM\_2.tif,TSEM.3.tif | Source image of the device |
| Source Data Fig. 2 | A1V.csv,A2V.csv,A0V.csv,A4V.csv,A5V.csv,A6V.csv,M0V.csv,M1V.csv,M1.5V.csv,M2V.csv,M3V.csv,M4V.csv,M5V.csv | Source optical transmission data |
| Source Data Fig. 3 | A2V.csv,A4V.csv,A6V.csv, left\_10G.jpg,right\_10G.jpg,Fig\_3b.zip | Source data and image containing data |
| Source Data Fig. 4 | 64G.jpg, 25\_1V.s2p,25\_2V.s2p,83\_3dB\_0.s2p,83\_0p5.s2p,83\_3dB\_1.s2p,83\_3dB\_2.s2p | Source data and image |
| Source Data Table.1 | 6dB.s2p,Eye1.jpg,Eye2.jpg,Eye3.jpg,Eye4.jpg.Eye5.jpg | Source data and image |

Fig.1 Integrated silicon MOS modulator. a, Cross-section schematic of the polysilicon/Si MOS capacitor ring resonator modulator design. b, Scanning electron microscope image of the fabricated MOS ring resonator modulator. The bus waveguide and ring positions are labelled. c, Transmission electron microscope image of the polysilicon/SiO2/Silicon MOS rib waveguide. d, Transmission electron microscope image of the cross-section of the whole MOS junction including electrodes contacting the highly doped p and n regions.

Fig.2 Static EO response of the MOS ring modulator. (a) Schematic drawing of modulator working at Vg > VFB (MOS flat band voltage) indicating where carrier accumulation happens in the MOS accumulation mode. (c) Measured spectral response for Vg ≥ 0 V. (b) Schematic drawing of MOS working at Vg ≤ Vin (MOS inversion voltage) indicating where carrier accumulations happen in the MOS inversion mode. (d) Measured spectral response for Vg ≤ 0 V. (e-f) show the gate voltages VS MOSCAP ring propagation loss in (e), single circulation amplitude attenuation factor a and the self-coupling coefficient t in (f), Q-factors and resonance wavelength changes in (g). Transmission loss in different situations are compared in (h). For carrier wavelength with “ER+” effect, one level IL starts from 1.8 dB and then significantly increases to 25 dB. While for the “ER-” effect, the IL changes between 1.8 dB and 3.8 dB.

Fig. 3 Frequency response of absorption enhancement. (a) Setup used to measure the modulation ER of the electro-optic modulation in different operation modes. EDFA, erbium-doped fiber amplifier. BPF, band pass filter. DCA, Digital Communication Analyzer (DCA 86100D). TLS, tunable laser source. CLOCK, clock signal generator. (b) Carrier absorption effect induced modulation ER enhancement (ER+) at optical wavelengths on the left sides of the resonance wavelength, and modulation ER suppression (ER-) for the optical wavelengths on the right side of the resonance wavelength. (c) Comparison of the high speed response of the two effects “ER+”, “ER-” in accumulation mode (Vg=4V) and inversion mode (Vg=-4V). Measured optical eye diagrams in accumulation mode at data rate of 10 Gb/s with “ER-” effect (d) and “ER+” effect (e), with gate voltage at 4V and RF Vpp=2V and optical IL 6dB.

Fig. 4 EO bandwidths of inversion and accumulation modes. (a) Setup used to measure the EO bandwidth of the ring resonator. LCA, lightwave component analyzer. (b), Setup used to test data transmission of the electro-optic modulation. EDFA, erbium-doped fiber amplifier. BPF, band pass filter. DCA, Digital Communication Analyzer (DCA 86100D). BPG, bit pattern generator (SHF 12104A). MUX (SHF 603B). TLS, tunable laser source. (c), Measured and normalized EO bandwidth of the MOS ring resonator modulator with Vg at 0.5V-2V with different lengths of active segments 25 µm and 83 µm. (d), Measured optical eye diagram with average at data rate of 64 Gb/s for MOSCAP ring modulator with active length 83 µm.

1. **Additional Supplementary Data**

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| Type | Number  Each type of file (Table, Video, etc.) should be numbered from 1 onwards. Multiple files of the same type should be listed in sequence, i.e.: Supplementary Video 1, Supplementary Video 2, etc. | Filename  Whole original file name including extension. i.e.: *Smith\_ Supplementary\_Video\_1.mov* | Legend or Descriptive Caption  Describe the contents of the file |
| Supplementary Data | Source Data for Supplementary Fig-I-1 | Fig. I-1.zip | Original data for Fig.I-1 |
| Supplementary Data | Source Data for Supplementary Fig-I-2 | Fig. I-2.zip | Original data for Fig.I-2,FigI-3,Fig-4 |
| Supplementary Data | Source Data for Supplementary Fig-I-5 | Fig. I-5.zip | Original data for Fig.I-5 |
| Supplementary Data | Source Data for Supplementary Fig-I-6 | Fig. I-6.zip | Original data for Fig.I-6 |
| Supplementary Data | Source Data for Supplementary Figures-I-7 | Fig. I-7.zip | Original data for Fig.I-7 |
| Supplementary Data | Source Data for Supplementary Figures-I-8 | Fig. I-8.zip | Original data for Fig.I-8 |
| Supplementary Data | Source Data for Supplementary Figures-III-1 | Fig. III-1.zip | Original data for Fig.III-1 |
| Supplementary Data | Source Data for Supplementary Fig-III-3,Fig-III-4,Fig-III-5 | Fig. III-3.zip | Original data for Fig.III-3/4/5 |
| Supplementary Data | Source Data for Supplementary Fig-IV-1 | Fig. IV-1.zip | Original data for Fig.I-1 |
| Supplementary Data | Source Data for Supplementary Fig-IV-2 | Fig. IV-2.zip | Original data for Fig.I-2 |
| Supplementary Data | Source Data for Supplementary Fig-IV-3 | Fig. IV-3.zip | Original data for Fig.I-3 |