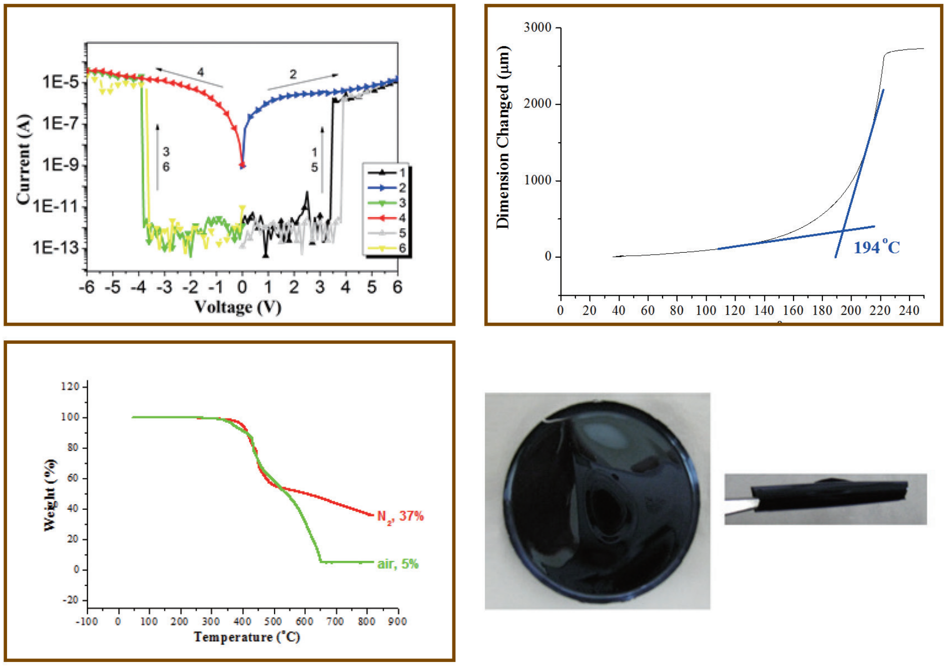

Figure 2. Current–voltage (I–V) characteristics of ITO/ZnPor-t-DSDA (50 ± 3 nm)/Al memory device; Softening and decomposition temperatures measured by TMA and TGA; the appearance of ZnPor-t-DSDA film.

Silicon carbide micro-ring all-optical processor

Silicon (Si) photonics are able to overcome the transmission degradation induced by the limited RC time constraint in electronic integrated circuits via electro-optical switching or all-optical processing. Si photonic components, including light sources [1], waveguides [2,3], and photodiodes, have been developed to construct all-optical transmission platforms on a chip. When considering the optical processing, optical excitation or electrical injection can change the absorbance and refractive index or induce free carriers in Si-based materials, which facilitates switching and modulation via ring resonators or Mach-Zander interferometers. Nevertheless, the free-carrier lifetime in bulk Si remains beyond the nanosecond range, thus limiting the switching or modulation bandwidth. Using the optical nonlinearity of Si is an alternative way to realize the same functionality for all-optical data processing at a high speed in next-generation devices. Two major all-optical switching mechanisms, including two-photon-absorption (TPA)-induced free-carrier absorption (FCA) and the nonlinear Kerr effect, have been considered; however, TPA-induced FCA modulation requires more time to dissipate free carriers, which delays the device response. Meanwhile, nonlinear Kerr switching is another way to achieve ultrafast data processing under a high-intensity pump or with a strongly nonlinear refractive index.

In Si photonics, the bulk Si integrates many optoelectronic components on a chip. However, bulk Si has some limitations for all-optical modulation, even when it is compatible with CMOS fabrication technology, and it exhibits a small nonlinear refractive index that practically limits its application in nonlinear optical processing. Additionally, FCA dominates the switching mechanism in bulk Si and degrades its high-speed performance. In contrast, Si carbide (SiC) has emerged as an alternative because of its stronger nonlinearity than that of other Si-based materials, which also provides a higher thermal stability to enable operation at higher intensities. Therefore, SiC is a potential candidate for performing high-speed data processing based on its optical nonlinearity. In this work, a SiC-based ring resonator is used to demonstrate high-speed cross-wavelength wavelength conversion and format inversion by employing the nonlinear Kerr effect, as shown in Figure 1.

The Si quantum dots embedded in SiC induce quantum confinement to increase the nonlinear refractive index of the SiC material to as high as 3×10^{-13} cm^2/W. This enhanced nonlinear refractive index temporarily contributes to a redshift of 0.07 nm in the transmission spectra under high-intensity injection, as shown in the lower left part of Figure 2. Under a data stream with a 12-Gbit/s pulsed return-to-zero on-off keying (PRZ-OOK) format, the SiC-based ring resonator can demonstrate wavelength conversion and data inversion owing to the nonlinear Kerr effect, as shown in the lower right part of Figure 2. In addition, the signal-to-noise ratio of the modulated data stream is 9.4 dB with a penalty degradation of 2.6 dB relative to that of the optical pump. The rise and fall times of the inverted probe that are shorter than 43 ps remain identical to those of the pumping signal, indicating a distortion-free replication of the pumping format on the modulated probe.

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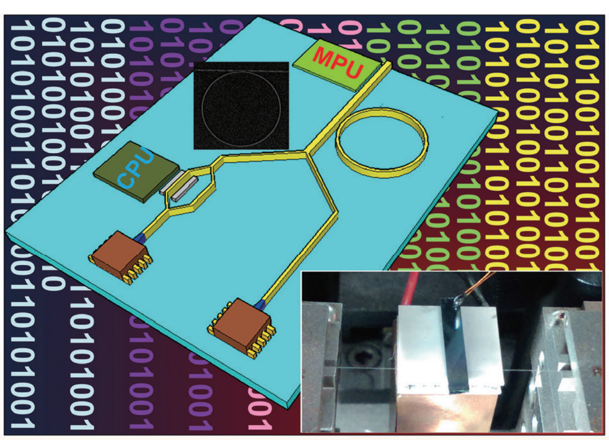

Figure 1. Schematic diagram showing the SiC-based ring resonator on the Si platform. Upper inset: Scanning electron microscope image of the SiC-based ring resonator. Lower right inset: experimental setup of the pump-probe system.

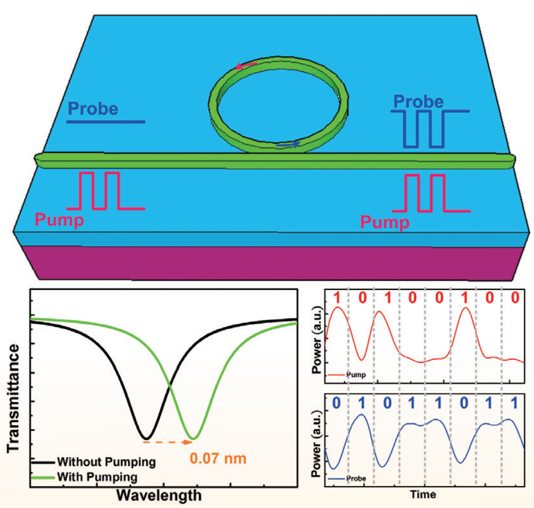

Figure 2. Upper: Schematic diagram of the SiC-based ring resonator for inverted data conversion with the nonlinear Kerr effect. Lower left: transmission spectra of the SiC-based ring resonator. Lower right: pulse traces of the 12-Gbit/s PRZ-OOK optical pumping and the modulated probe signal in inversion format.