A new platform for integrated photonics

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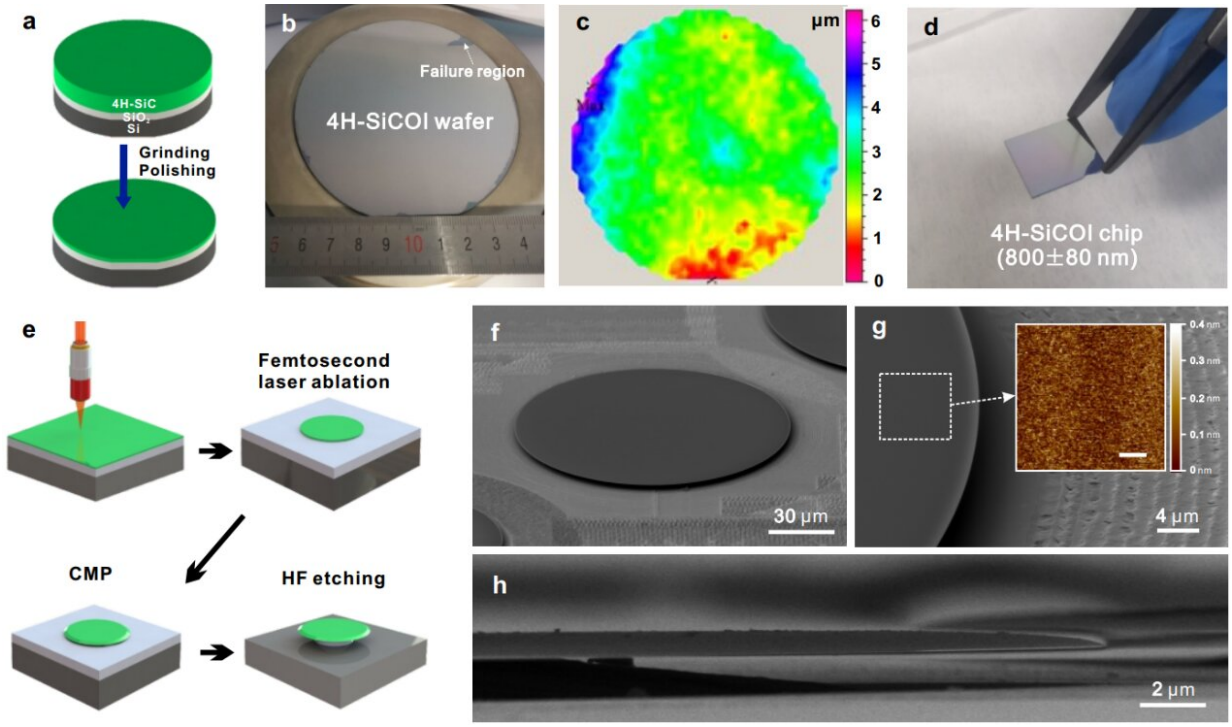


(a) Fabrication process of pristine 4H-SiCOI material platform. (b) Photograph of a 4-inch wafer-scale 4H-SiCOI substrate fabricated using bonding and thinning method, the failure region is marked. (c) Total thickness variation of the 4H-SiCOI substrate. (d) Image of a 4H-SiCOI die. (e) Flowchart of fabricating a SiC microdisk resonator. (f) A scanning electron micrograph (SEM) of the fabricated microdisk resonator. (g) Zoom-in SEM image of the sidewall of the resonator. Inset, the atomic force micrograph (AFM) scan of the top surface of the resonator. (h) Side view SEM image of the fabricated resonator with parabolic-like shaped upper surface. Credit: Chengli Wang, Zhiwei Fang, Ailun Yi, Bingcheng Yang, Zhe Wang, Liping Zhou, Chen Shen, Yifan Zhu, Yuan Zhou, Rui Bao, Zhongxu Li, Yang Chen, Kai Huang, Jiaxiang Zhang, Ya Cheng and Xin Ou

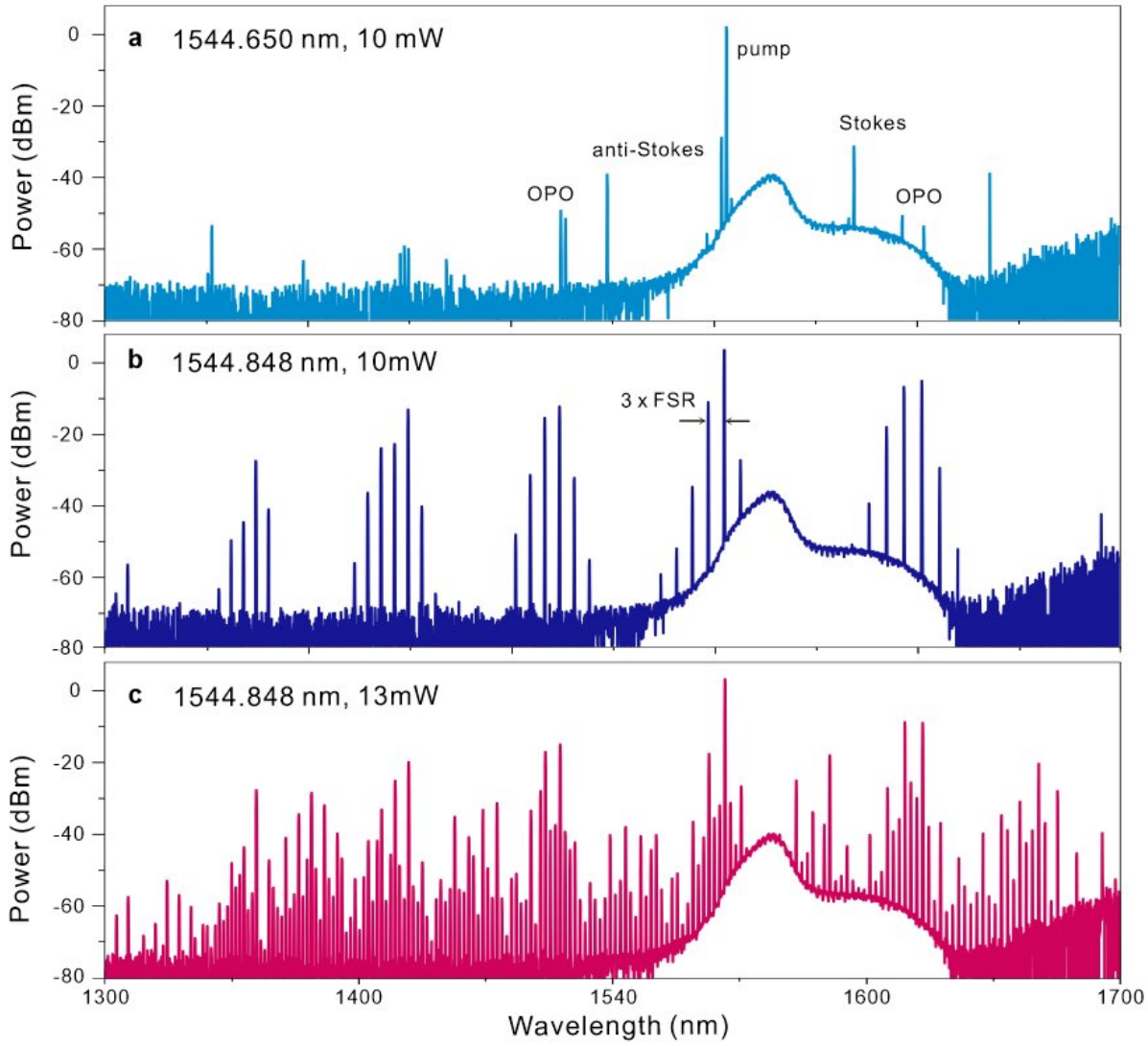
SiC photonics has been developed for over a decade, one of the major obstacles is the difficulty of fabricating ultralow optical loss SiC thin-films. Scientists in China have fabricated an ultralow loss 4H-SiCOI platform with a record-high-Q factor of 7.1×10^6. Nonlinear photonics process, including second-, third- and fourth-harmonic generations, Raman lasing, and Kerr frequency combs have been observed. This demonstration represents a milestone in the development of SiC photonic devices.

Photonic integrated circuits (PICs) and microresonators have attracted strong interest in photonics community. For applications, achieving low optical loss is crucial. SiC PICs have been in development for over a decade, a lot of works have been carried out on the SiC thin films prepared by heteroepitaxial growth. However, the quality factor of these devices is limited to less than 10^6 due to the high density of crystal defects near growth interface. Up to now, how to further reduce the optical loss of SiC thin films has become the primary problem for scientist to explore the advantages of SiC in PICs applications.

In a new paper published in *Light Science & Application*, a team of scientists, led by Professor Xin Ou from State Key Laboratory of Functional Materials for Informatics, Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, and co-workers have fabricated an ultralow loss 4H-SiCOI platform with a record-high-Q factor of 7.1×10^6. The 4H-SiCOI platform prepared by wafer-bonding than thinning techniques, enables the same crystalline quality as bulk high-pure 4H-SiC crystal. The high Q resonators were used to demonstrate various nonlinear processes including generation of multiple harmonics up to the fourth order, cascaded Raman lasing, and Kerr frequency comb. Broadband frequency conversions, including second-, third-, fourth- harmonic generation (SHG, THG, FHG) have

been observed. Cascaded Raman lasing with Raman shift of 204.03 cm^{-1} has been demonstrated in SiC microresonators for the first time. Using a dispersion-engineered SiC microresonator, Kerr frequency combs covering from 1300 to 1700 nm have been achieved at a low input power of 13 mW.

The demonstration of high Q SiC photonics devices represents a significant milestone in the development of SiC PICs. This work was also highly praised by the reviewers. "In my opinion, this work is novel, sound and important. I believe this work will bring a huge momentum for SiC integrated photonics in the next few years", "I believe this work will be a milestone for SiC photonics", "The presented work here shows microresonator with Q up to 7.1×10^6, which is certainly a major breakthrough in the development of photonic devices that harness the unique optical properties of SiC".



(a) Measured OPO spectra generated with a launched pump power of 10 mW. (b) Hyper-OPO spectra generation when red-tuned the pump wavelength into resonance near 1544.848 nm. (c) Broadband Kerr frequency comb generations when a 13 mW pump was injected into the microresonator at 1544.848 nm. Credit: Chengli Wang, Zhiwei Fang, Ailun Yi, Bingcheng Yang, Zhe Wang, Liping Zhou, Chen Shen, Yifan Zhu, Yuan Zhou, Rui Bao, Zhongxu Li, Yang Chen, Kai Huang, Jiaxiang Zhang, Ya Cheng and Xin Ou

More information: Chengli Wang et al, High-Q microresonators on 4H-silicon-carbide-on-insulator platform for nonlinear photonics, *Light: Science & Applications* (2021). DOI: 10.1038/s41377-021-00584-9