Docket #: S18-553

Silicon-Carbide-on-Insulator (SiCOI) Fabrication

Stanford researchers in the Vuckovic group have fabricated thin-film 4H crystal structure Silicon Carbide with excellent quantum and classical photonics properties. 4H - SiC hosts color centers (point defects), useful for a variety of quantum and classical photonics applications. Like most polymorphs, 4H-SiC can only be grown homoepitaxially, so thin films of 4H-SiC cannot be grown directly. Current means of thin-film 4H-SiC fabrication (similar to the SmartCut process) produce lossy, low quality films.

In response, Vuckovic's researchers developed an alternative using bonding, thinning and polishing techniques. To produce films of 4H-SiC on SiO_2 on Si (Silicon-Carbide-on-Insulator or SiCOI) they use oxide-oxide bonding, wafer thinning based on grinding and reactive ion etching, and chemical-mechanical polishing. (See figure 1.)

This process produces 4H-SiC thin films with high yield and pristine crystal quality, and can be scaled up to wafer size for manufacturing. The technique works for other polymorphs, and will improve the crystal quality of 3C-SiC thin films compared to heteroepitaxially grown 3C-SiC on Si films and films produced using Smart-Cut. Researchers are using the technique to produce and test quantum and classical photonic, and electronic devices.

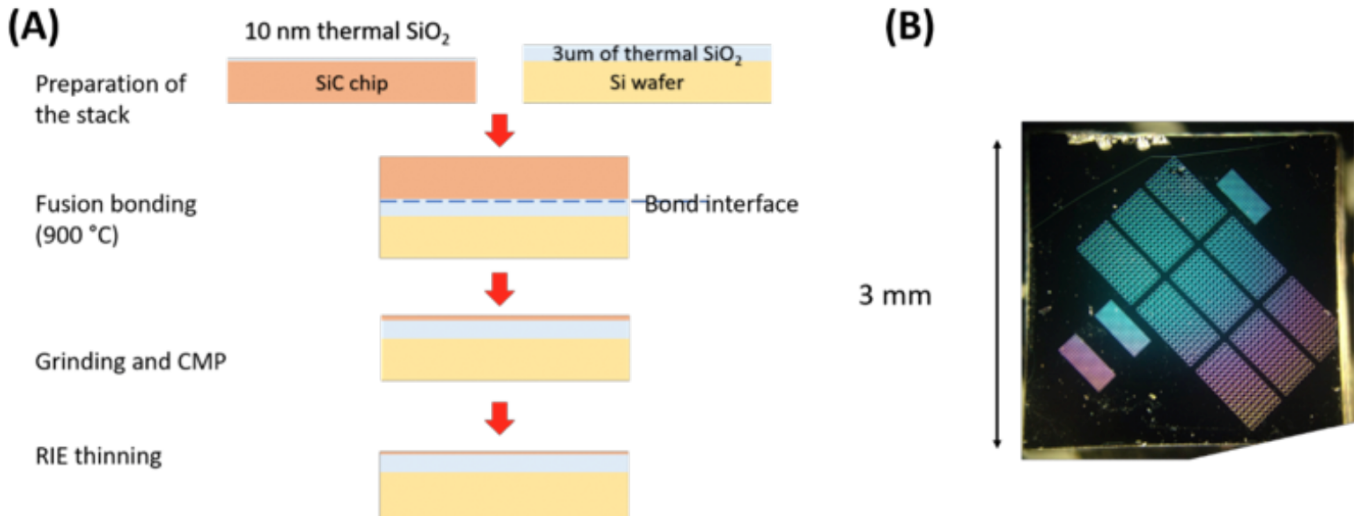


Figure 1: (A) Illustration of the process flow. (B) Image of a chip with 4H-SiCOI photonic devices. Note: for industry scaling, Si handle wafers (as opposed to SiC) would be used, because thermal stresses during and after bonding could detach the SiC wafer bonded to SiO2 on Si.

Applications

- Quantum electronics, quantum photonics, and quantum sensors
- Microwave photonics, classical photonics, LEDs
- Electric systems, electronics, power electronics
- Thin filament pyrometry, heating elements

Advantages

- High yield and pristine crystal quality
- **10-fold reduction in waveguide losses** compared to techniques such as Smart Cut^{TM}.
- Integrated photonics and integrated electronic circuits in SiC – higher speed optical devices, quantum emitters (quantum cryptography, in vivo biolabeling), etc.

Publications

- D.M. Lukin, C. Dory, M.A. Guidry, K.Y. Yang, S.D. Mishra, R. Trivedi, M. Radulaski, S. Sun, D. Vercruysse, G. H. Ahn, J. Vuckovic 4H-silicon-carbiode-on-insulator for integrated quantum and nonlinear photonics *Nature Photonics*, December 2, 2019.

Patents

- Published Application: 20200279767
- Published Application: 20210398804
- Issued: 11,996,285 (USA)

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