

Integrated-Optic Free-Space-Wave Coupler for Package-Level On-Board Optical Interconnects

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Abstract—A cavity-resonator integrated grating input/output coupler (CRIGIC) gives high-efficiency vertical coupling with small aperture suitable for high-density intraboard optical interconnection. Design and preliminary experimental results of simple CRIGIC on a Si substrate were described. Integration of CRIGIC and a different-guided-mode-coupling distributed Bragg reflector was proposed and discussed to provide free-space-wave optical add/drop multiplexing (FOADM) function for an application to a future high-performance signal-processing system in package using wavelength division multiplexing optical interconnection. A scheme of eight-wavelength multiplexing system within 20-nm wavelength range was investigated. FOADM devices were designed and their performances were simulated theoretically.

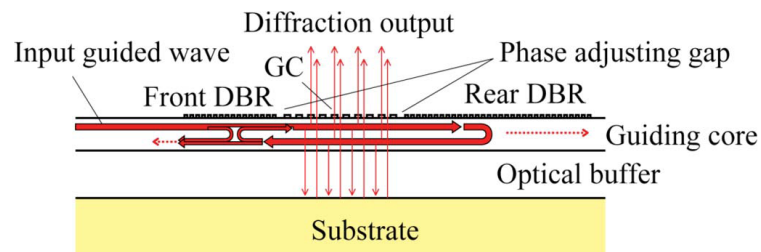


Fig. 2. Cross-sectional view of basic configuration of CRIGIC.

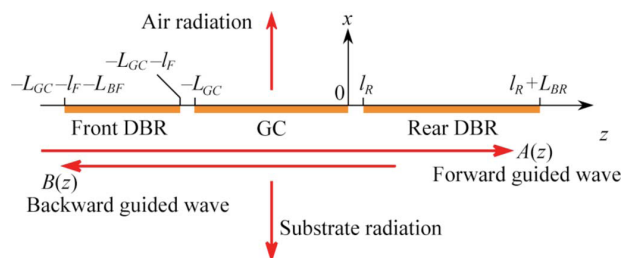


Fig. 3. Coordinate system, the denotation of guided waves, and the positions and coupling lengths of gratings.

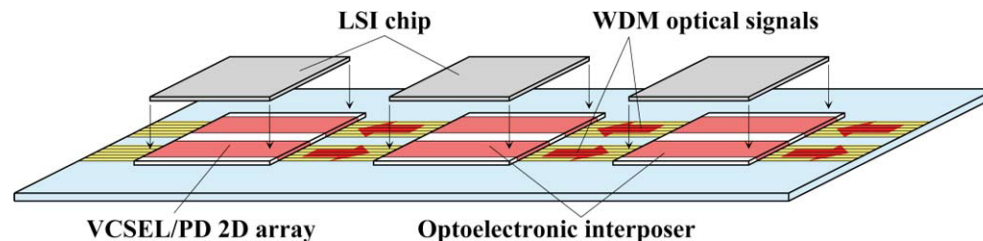


Fig. 1. Concept image of WDM-OI SiP. 2-D parallel optical signals from VCSEL 2-D array are transmitted as WDM signals in thin waveguides to PD 2-D array.

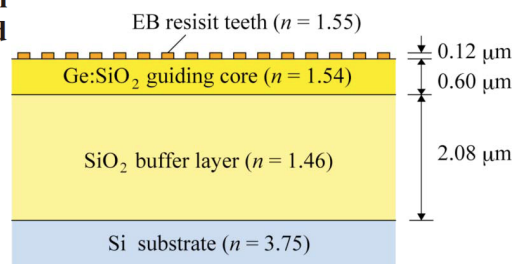


Fig. 4. Cross-sectional diagram of waveguide and gratings of designed simple CRIGIC on Si substrate.

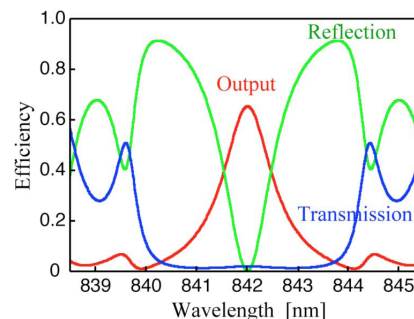


Fig. 5. Transmission, reflection, and output coupling efficiencies of 20-μm aperture CRIGIC calculated by coupled-mode analysis.

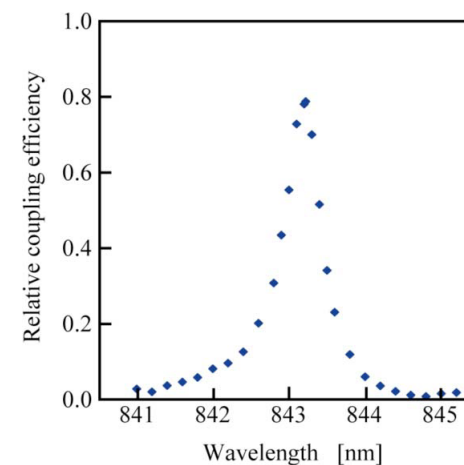


Fig. 6. Measured wavelength dependence of the ratio of the output power from CRIGIC of 20-μm aperture against the output power from GC of 500-μm coupling length.

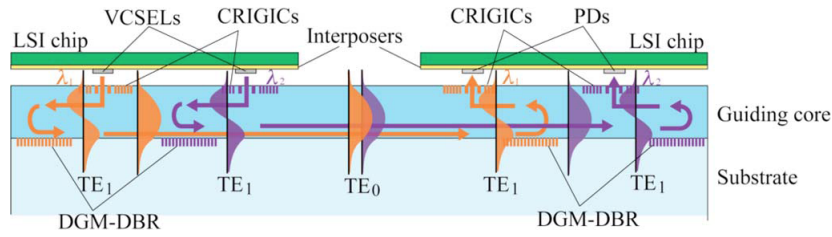


Fig. 7. Cross-sectional image of WDM signal transmission using CRIGICs and DGM-DBRs.

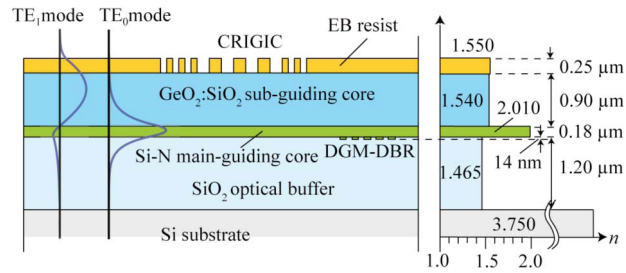


Fig. 8. Cross-sectional diagram of designed FOADM structure with refractive index profile and calculated electric field distributions of guided modes.

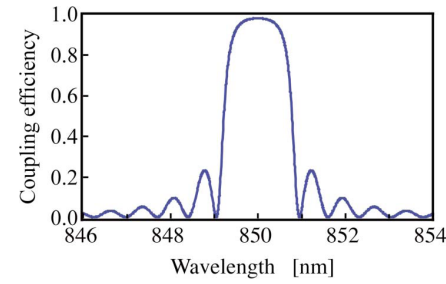


Fig. 9. Calculated wavelength dependence of the coupling efficiency of contra-directional TE_0 and TE_1 modes by DGM-DBR.

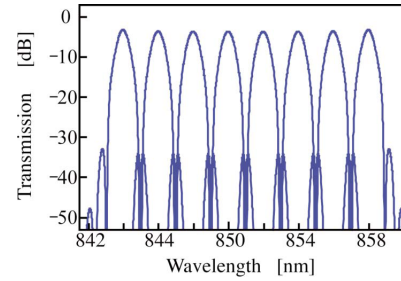


Fig. 7. Cross-sectional image of WDM signal transmission using CRIGICs and DGM-DBRs.

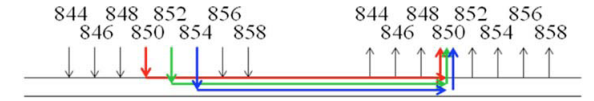


Fig. 10. Calculated transmission efficiencies of eight WDM channels. The maximum efficiency is predicted to be -3.7 dB.

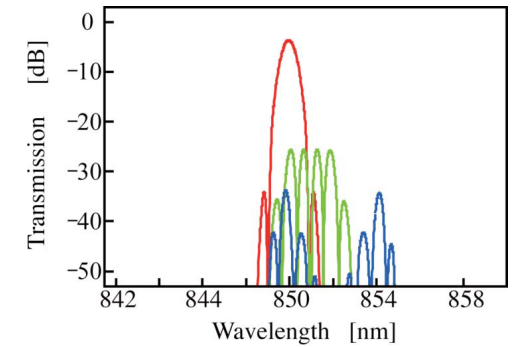


Fig. 12. Calculated transmission of different signal waves from different transmission points to a certain detection point.