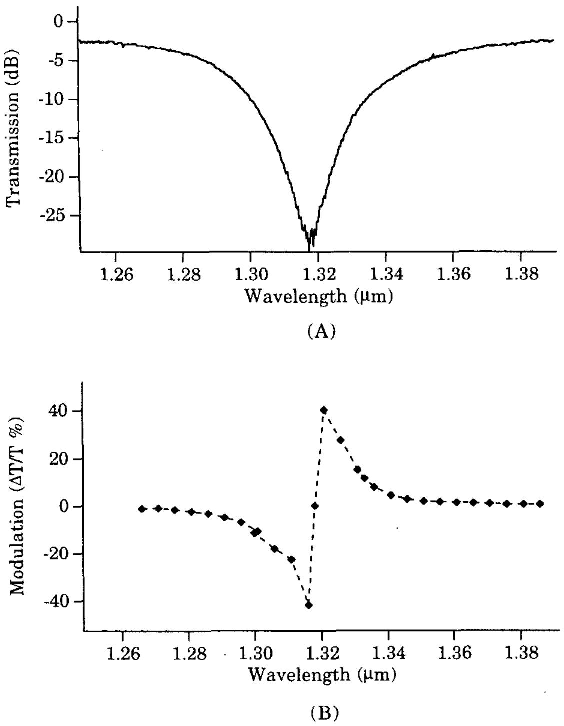

WL1 Fig. 2. The transmission dip (A) obtained by phase matching the fiber-guided mode and a mode of the polymer overlay and the modulation (B) achieved with a 15-V amplitude modulating voltage.

dure. This procedure (Fig. 1) involves the deposition and corona poling of a nonlinear polymer film on a release layer and temporary substrate. Following preparation, the film is cut to size and released from the temporary substrate by dissolving the release layer. The released nonlinear polymer film is then deposited onto a metal-coated, fiber half-coupler and a second electrode is deposited onto the polymer film.

Modulation is achieved by altering the phase-matching conditions between the fiber and the polymer waveguide. This is achieved via the linear electro-optic effect in the nonlinear polymer, therefore, the modulation bandwidth is limited only by the electrode structure of the device. Results have indicated that the phase-matched condition results in transmission losses of greater than 30 dB while the non-phase-matched condition results in losses of less than 1 dB. The potential exists for devices with extremely large bandwidths and dynamic ranges.

Preliminary measurements were made on a device with approximately 2-μm remaining fiber cladding, a 10-nm gold lower electrode, a 3.5-μm corona poled layer of poly (Disperse Red 1 methacrylate-co-methyl methacrylate), and a 200-nm aluminum top electrode. The device characteristics were measured using a TM-polarized source operating in the 1.3-μm window and a 15-V amplitude modulating voltage. The results, showing the transmission dip and a maximum modulation of 40%, are shown in Fig. 2. Modulation has been observed at frequencies up to 100 MHz, limited by the electrode design. We are pursuing a traveling wave electrode design that will permit extremely high-speed operation.

These devices are mechanically rugged, due to the self-pigtailed design, and could be fabricated for a fraction of the cost of similar lithium niobate modulators. This fabrication procedure can easily be adapted to other devices and allows the deposition of high-quality, corona-poled, nonlinear polymer films onto structures without subjecting them to spin coating, large electrostatic fields, or other processing steps that may damage the device. The procedure eliminates the damage that has been associated with corona poling of electro-optic structures[3] and allows films of identical thickness to be deposited onto different devices.

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WL2 3:32 pm

Epitaxial lift-off arrays of GaAs LEDs over wafer-scale Si VLSI for optical interconnect technology

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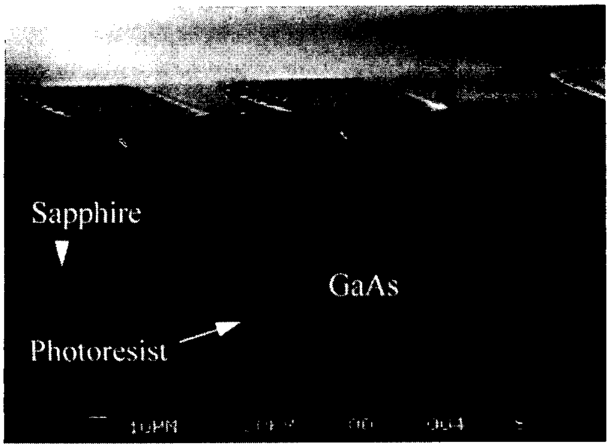
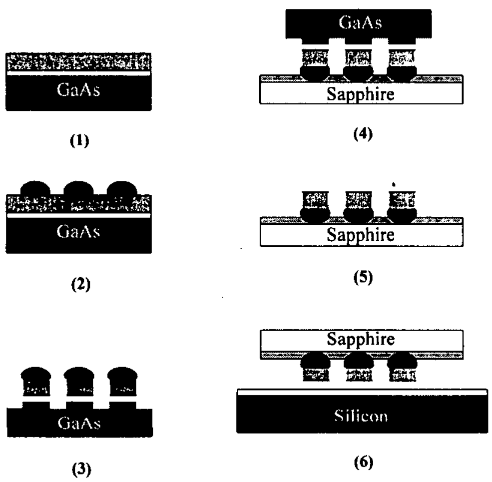
The use of GaAs components (devices, ICs, etc.) onto Si circuitry has unveiled a new dimension in optical communication systems packaging. Current integration techniques like heteroepitaxy,[1] flip-chip bonding[2] and thin-film grafting,[3,4] though interesting, are still far away from the goal of reducing complexity and cost for high-volume manufacturing. The technique discussed in this paper demonstrates the integration of arrays of GaAs LEDs over large wafer-scale Si VLSI driver circuitry. GaAs LEDs, designed to operate at 870 nm, are used for their lower device complexity and higher reliability and yield. This integrated system is considered important for high-density short-distance free-space optical interconnects in MCMs or local area network (LAN) when coupled with optical fibers.

Herein we report a manufacturable epitaxial lift-off (ELO) technique to integrate arrays of discrete thin films from a 2" GaAs wafer with MBE-grown LEDs onto a 5" foundry fabricated Si wafer with LEDs driver circuitry on each die. GaAs wafer was first patterned and covered with 5-μm-thick photoresist. After hard baking, photoresist can be made to be more than 10 μm, which gives enough etching channels to later allow hydrofluoric (HF) acid to penetrate under the GaAs wafer and uniformly lift-off all the devices. Before the HF etching step, GaAs wafer are bonded to a sapphire disk for mechanical support during lift-off and transfer. An SEM photograph demonstrates LED thin films which "stand-up" on the sapphire disk after ELO is shown in Fig. 1. After the ELO process, GaAs thin films, which are now carried on a sapphire disk, were transferred and bonded onto Si wafers. This ELO process se-



WL2 Fig. 1. SEM photograph of ELO LEDs thin films on sapphire disk.



WL2 Fig. 2. Manufacturable ELO process sequence: (a) As-grown GaAs wafer; (2) Thick photoresist patterning; (3) Mesa etching; (4) Sapphire disk carrier attachment; (5) ELO process; (6) Aligning and bonding onto Si wafer.

quence is illustrated in Fig. 2. The use of transparent sapphire carrier is to our advantage for precise alignment of GaAs devices onto Si wafers. To make this process manufacturable and cost-effective, wafer-scale lift-off, bonding, and materials cost reduction are required. This is made possible by the new developed selective ELO technique. The idea is to lift-off only certain regions of a GaAs wafer while retaining the availability of the others. By doing this, GaAs wafers can be reused and the cost of materials tremendously reduced. The details of this process, thin-film bonding technique, alignment accuracy, and the performance of the LEDs on Si will be presented in the conference.

In conclusion, we have developed a manufacturable and cost-effective ELO process to integrate a 2″ GaAs wafer, containing LEDs, over 5″ Si wafer with functioning dies. Using selective ELO process, only four processing steps are required to place devices from a 2″ GaAs waver to cover a whole 5″ Si. The same idea can be extended to fabricate even larger GaAs (e.g., 4″) and Si (e.g., 8″) wafers. The availability of this component integration process will be extremely valuable in future high-performance, reliable and low-cost optoelectronic communication systems.

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WL3 3:34 pm

Hybrid integrated bi-directional transmitter/receiver optical module based on silica waveguide using alignment-free hybrid assembly technique

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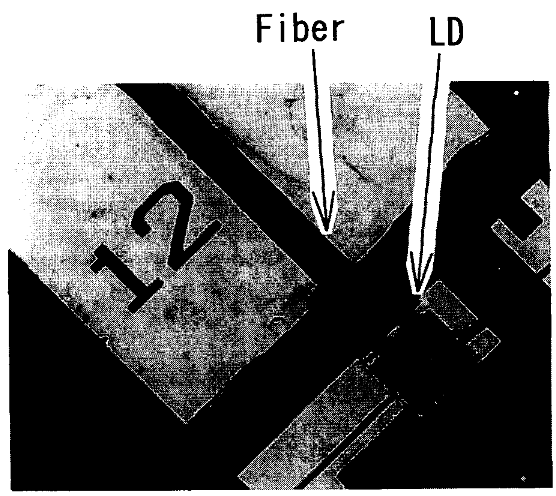
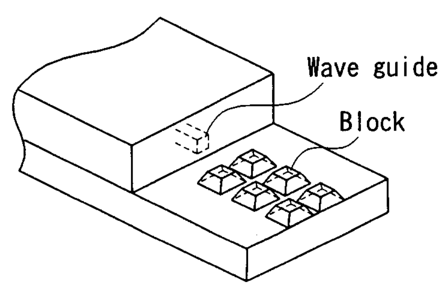
Reduction of optical module cost is strongly required in passive optical networks. A bi-directional transmitter/receiver op-



WL3 Fig. 1. LD-fiber optical coupling unit.



WL3 Fig. 2. Fiber alignment block.