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Indirect Wafer Bonding and Epitaxial Transfer of GaSb-Based Materials

M. GRZESIK,[1,3] S.R. VANGALA,[2] and W.D. GOODHUE[1,2]

1.—MIT Lincoln Laboratory, Lexington, MA, USA. 2.—University of Massachusetts, Lowell, MA, USA. 3.—e-mail: m.grzesik@ll.mit.edu

Results from a study of indirect wafer bonding and epitaxial transfer of GaSb-based materials are presented. Benzocyclobutene (BCB) was used as a bonding agent to bond GaSb and epitaxial structures lattice matched to GaSb onto Si, GaAs, and sapphire carrier substrates. To better understand sources of stress during the bonding process, which can result in cracking and subsurface damage of the GaSb-based materials, BCB's hardness and reduced elastic modulus were measured at various stages during the curing process. Based on the results of curing experiments, a bonding and epitaxial transfer process for GaSb-based materials was then developed. Following bonding, using an experimentally determined low-stress cure cycle, GaSb substrates were removed from epitaxial layers of InAsSb using a combination of mechanical thinning and polishing followed by selective chemical etching using a hydrofluoric and chromic acid solution. Etch selectivity data are also presented where selectivity greater than 100:1 is achieved for GaSb:InAsSb.

Key words: Wafer bonding, GaSb, BCB, InAsSb, selective etch, mechanical properties

INTRODUCTION

Organic polymers have found use in semiconductor fabrication due to their desirable thermal, mechanical, and electrical properties. In particular, benzocyclobutene (BCB) from Dow Chemical Co., commercialized under the name Cyclotene®, has been used extensively in microelectronic and optoelectronic fabrication. A low dielectric constant, strong adhesion, low moisture absorption, and planarization properties have allowed BCB to be used for a variety of applications. These include optical waveguides,[1,2] interlayer dielectrics in the fabrication of interconnects for multichip modules,[3,4] sidewall passivant for mesa photodiodes,[5] and as an adhesive for indirect wafer and die bonding.[6,7] For wafer and die bonding, BCB provides a new scheme for hybridization of III–V detector arrays and silicon readout integrated circuits (ROICs). This hybrid integration is advantageous because it allows for separate optimization of the detector arrays and Si-based readout electronics. Typically, detector and readout circuit integration is accomplished using indium bump bonding technology. The drawbacks of this methodology are that standard indium bump widths limit detector pitch and alignment accuracy is limited by the reflow of the indium bumps. The use of BCB for wafer and die bonding allows for decreased detector pitch and finer alignment tolerances compared with conventional indium bump bonding.

With the realization of III–V devices lattice matched to GaSb, indirect wafer bonding using BCB was examined as a possible low-stress method for wafer hybridization and epitaxial transfer. GaSb-based devices that can benefit from epitaxial transfer include back-illuminated focal-plane arrays and thermophotovoltaic cells. In both cases, flipping and bonding allows for thinning or removal of the GaSb substrate, which reduces free carrier absorption, increasing device performance. With several device and packaging schemes in mind, experiments were carried out aimed at bonding GaSb epitaxial wafers to one of three carrier substrates: Si, GaAs, and sapphire.

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