# The feasibility of wafer bonding by Indium Tin Oxide intermediate layer for light emitting diodes


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Compound semiconductor direct-wafer-bonding has been used to fabricate GaAs optoelectronic devices such as surface emitting lasers and light-emitting-diodes. However, bonding processes were usually performed at elevated temperatures, which may degrade the quality of the epitaxial structure. In addition to this, a unavoidable twist misorientation between two wafers caused screw dislocation networks at the interface and resulted in an increase of electrical resistance of bonded interfaces. Bonding the wafers with a polycrystalline intermediate layer at low temperature may solve these two problems. In this study, the feasibility of bonded wafer by indium tin oxide (ITO) intermediate layer was investigated. By using this film, GaAs wafers can be bonded at temperature lower than 650℃. After bonding, the snowflake-like features seen in fig. 1 correspond to the bonded areas, which were found to increase with the bonding temperature. We also found that the electrical resistance decreased with the bonding temperature, as shown in Fig. 2. When the bonding temperature reached 650°C, the electrical resistance was about 3.94Ω. The tensile strength of the bonded pair was larger than 5 MPa which could endure the dicing process. Optical loss estimation was preformed by bonding two ITO coated glasses together. The optical losses were less than 7.2% when the bonding temperature reached than 600 ℃ (as shown in Fig. 3). The process developed in this study involves the use of a relatively uniform pressure and moderately low temperatures (<650°C) to produce optimal results. Using this procedure it was possible to fabricate bonded wafers in which the electrical resistance and optical losses were low enough for high brightness LEDs.

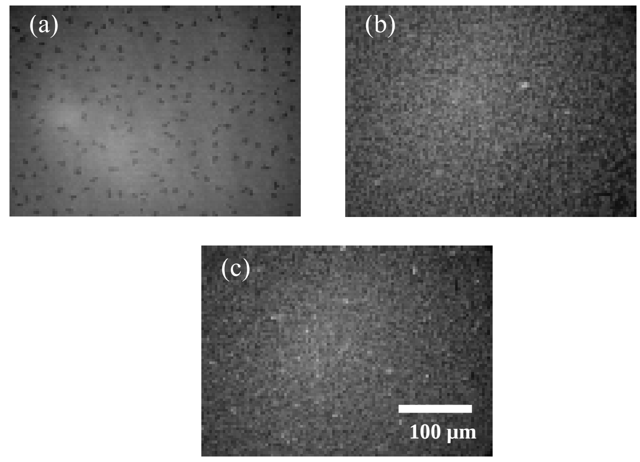


Fig. 1 IR transmission optical micrograph of GaAs interface after bonded at temperatures of (a) 500°C, (b) 550°Cand (c) 600℃ for 40 min.

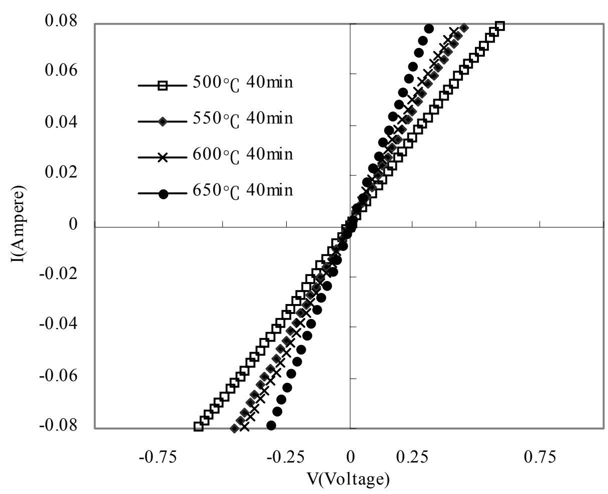


Fig. 2 Current–voltage (*I* –*V*) characteristics of wafer-bonded GaAs /$In_{0.5}Ga_{0.5}P$ - ITO/ GaAs interface (2╳2 $mm^2$ die) at bonding temperatures ranging from 500°Cto 650°C.

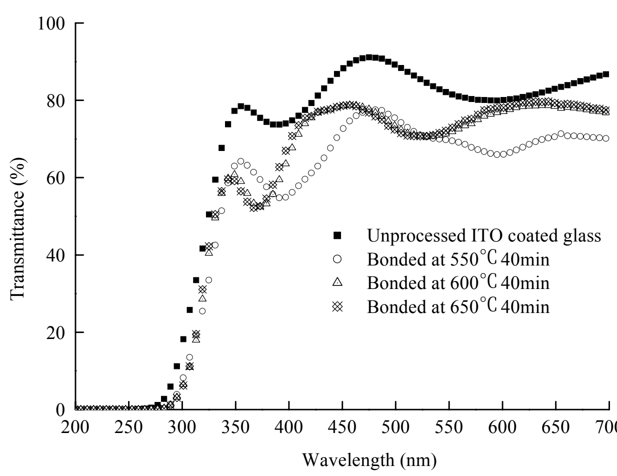


Fig. 3 Transmittance of glass substrates bonded for 2h at temperatures ranging from 500°Cto 650°C.