Ultra-high vacuum direct bonding of GaAs- to Si-wafer using low-energy hydrogen ion beam surface cleaning


UHV-direct wafer bonding is becoming an important method to join different semiconductor materials with each other. Wafer surfaces must be prepared to be mirror-polished, flat, and clean from foreign contamination and dust for successful joining by forming chemical bonds at the interface. For applications of this bonding technique in MEMS and MOEMS technology the bonding of GaAs and Si is very interesting. We performed a study of GaAs-to-Si bonding under UHV conditions. The wafers were cleaned using low energy (<500eV) hydrogen ion beam bombardment at low temperatures (<300°C) in order to achieve an oxygen and carbon contaminant as well as near damage free surface. The cleaned wafers are transported and brought together in contact for bonding and finally annealed to increase the bonding strength in UHV. In-situ and ex-situ infrared imaging of the as-bonded wafers show directly the bonding behaviour. High-resolution transmission electron microscopy images reveal that the wafers are bonded without damage of the crystal lattice or intermediate layer and that the interface is smooth. Current-voltage measurements are used for the electrical characterization of the bonding interface of homo-type (n-Si and n-GaAs) and heterotype (p-Si and n-GaAs) material bonding.