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Fabrication of Large Area Transmission Electro-Absorption Modulator with High Uniformity Backside Etching

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Surface-normal transmission electro-absorption modulator (EAM) are attractive for high-definition (HD) three-dimensional (3D) imaging application due to its features such as small system volume and simple epitaxial structure [1,2]. However, EAM in order to be used for HD 3D imaging system requires uniform modulation performance over large area. To achieve highly uniform modulation performance of EAM at the operating wavelength of 850 nm, it is extremely important to remove the GaAs substrate over large area since GaAs material has high absorption coefficient below 870 nm which corresponds to band-edge energy of GaAs (1.424 eV). In this study, we propose and experimentally demonstrate a transmission EAM in which highly selective backside etching methods which include lapping, dry etching and wet etching is carried out to remove the GaAs substrate for achieving highly uniform modulation performance. First, lapping process on GaAs substrate was carried out for different lapping speeds (5 rpm, 7 rpm, 10 rpm) and the thickness was measured over different areas of surface. For a lapping speed of 5 rpm, a highly uniform surface over a large area (2×1 mm^2) was obtained. Second, optimization of inductive coupled plasma-reactive ion etching (ICP-RIE) was carried out to achieve anisotropy and high etch rate. The dry etching carried out using a gas mixture of SiCl4 and Ar, each having a flow rate of 10 sccm and 40 sccm, respectively with an RF power of 50 W, ICP power of 400 W and chamber pressure of 2 mTorr was the optimum etching condition. Last, the rest of GaAs substrate was successfully removed by highly selective backside wet etching with pH adjusted solution of citric acid and hydrogen peroxide. Citric acid/hydrogen peroxide etching solution having a volume ratio of 5:1 was the best etching condition which provides not only high selectivity of 235:1 between GaAs and AlAs but also good etching profile [3]. The fabricated transmission EAM array have an amplitude modulation of more than 50% at the bias voltage of -9 V and maintains high uniformity of >90% over large area (2×1 mm^2). These results show that the fabricated transmission EAM with substrate removed is an excellent candidate to be used as an optical shutter for HD 3D imaging application.

Keywords: electro-absorption modulator, optical shutter, HD 3D imaging application

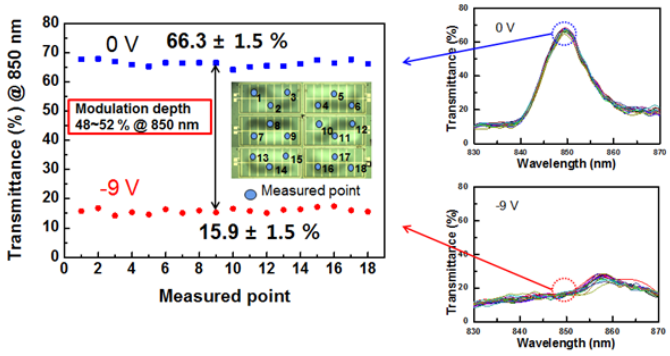

Figure 1. Measurement of transmittance over large area