TERAHERTZ OPTICAL HALL EFFECT IN AlScN/GaN AND AlYN/GaN HEMT STRUCTURES

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AlGaN/GaN high-electron-mobility transistors (HEMT) have enabled breakthroughs in high-power and high-frequency electronics. AlScN and AlYN provide a higher polarization gradient than AlGaN and hence increased sheet charge carrier density(n_s) of the two-dimensional electron gas (2DEG) if employed as barrier layers.

Here, we report THz Optical Hall effect(1)(OHE) in AlScN/GaN and AlYN/GaN HEMT structures, which allow for contactless determination of the 2DEG properties. The samples have ~10-nm thick barrier layers with Sc and Y content of 4.6-17.3% and 3.3-8.2%, respectively.(2) The OHE measurements were performed at magnetic field B=2.82T and temperatures T=10-370~K. The room temperature(RT) OHE results reveal high n_s=3-3.5x10^+13~cm^-2 for all Sc contents and mobility parameters of 520-600~V(s.cm)^-1. For the AlYN HEMT structures the mobility was found to be slightly higher, but for a lower n_s in the range 2-3x10^13~cm^-2. These results are corroborated by eddy-current sheet resistance and contactless Hall measurements.

The 2DEG electron effective mass parameters (m*) was determined at RT to be m*=0.34m0 for the AlScN/GaN HEMT structures, in agreement with results for AlGaN/GaN HEMTs.(1,3) For AlYN barrier structures, the RT 2DEG effective mass was determined to be significantly higher: 0.47m0. The analysis of the low temperatures (10-130K) OHE yielded 2DEG effective mass m*=0.23-0.27m0, much closer to the typically accepted value m*=0.23m0 for bulk GaN.(4) The causes for the peculiar behavior of the 2DEG effective mass are discussed in detail and possible explanation, associated with deviation from the classical Drude model is proposed.