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AlGaN/GaN/SiC high-electron-mobility transistors and Schottky diodes

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For many years, IIIA-nitrides have been researched and used to manufacture electronic components due to the unique properties of these materials [1]. GaN-based components containing two-dimensional electron gas (2DEG) are also applicable for the development of plasmonic emitters and sensors in terahertz (THz) frequency [2, 3]. The top quality electronic components are obtained by growing nitride layers on a native substrate [4], however bulk GaN substrates are still expensive and small in size. As a result, lower-quality components are usually grown on Si or Al_2O_3 substrates, while SiC is irreplaceable at high quality requirements.

Here we present a research on Schottky diodes (SDs) and high-electron-mobility transistors (HEMTs) made of heterostructures with different substrates. Heterostructures were grown at the Institute of High Pressure Physics (UNIPRESS), Poland, on a sapphire or semi-insulating 6H-SiC substrate by the metalorganic chemical vapor deposition (MOCVD) method. 2DEG density and electron mobility of the latter heterostructure were 8.3×10^{12} cm^{-2} and 1900 cm^2/(Vs) at room temperature and 6.9×10^{12} cm^{-2} and 17000 cm^2/(Vs) at 77 K, respectively.

The ohmic (Ti/Al/Ni/Au) and Schottky (Ni/Au) contacts were manufactured at the Center for Physical and Technological Sciences (FTMC) using UV photolithography, electron beam evaporation and rapid thermal annealing technology [3]. The ohmic contacts were optimized by selecting different metal thicknesses and annealing temperatures.

SDs and HEMTs made of AlGaN/GaN/SiC heterostructure demonstrated better electrical performance than that of analogous components made of sapphire-based heterostructures. For both SD and HEMT, lower leakage currents and higher current-switching ratios I_{ON}/I_{OFF} were observed. In addition, higher values of direct HEMT current were measured, resulting in a higher transconductance. Better electrical properties of the SiC-based components are due to a higher quality of epitaxial layers obtained by growing the nitrides on a SiC substrate.

A possibility to use such a HEMT without a special THz antenna as a sensor for imaging a commercially 0.3 THz source beam was demonstrated at room temperature. The parameters of the sensor could be improved by designing an appropriate THz antenna and by optimizing the dimensions of the sensor.

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