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Epitaxial MoS_2/GaN structures to enable vertical 2D/3D semiconductor heterostructure devices D. RUZMETOV, US Army Research Laboratory, K. ZHANG, Pennsylvania State University, G. STAN, B. KALANYAN, NIST, S. EICHFELD, PSU, R. BURKE, P. SHAH, T. O'REGAN, F. CROWNE, A.G. BIRDWELL, ARL, J. ROBINSON, PSU, A. DAVYDOV, NIST, T. IVANOV, ARL — MoS_2/GaN structures are investigated as a building block for vertical 2D/3D semiconductor heterostructure devices that utilize a 3D substrate (GaN) as an active component of the semiconductor device without the need of mechanical transfer of the 2D layer. Our CVD-grown monolayer MoS_2 has been shown to be epitaxially aligned to the GaN lattice which is a pre-requisite for high quality 2D/3D interfaces desired for efficient vertical transport and large area growth. The MoS_2 coverage is nearly 50 % including isolated triangles and monolayer islands. The GaN template is a double-layer grown by MOCVD on sapphire and allows for measurement of transport perpendicular to the 2D layer. Photoluminescence, Raman, XPS, Kelvin force probe microscopy, and SEM analysis identified high quality monolayer MoS_2. The MoS_2/GaN structures electrically conduct in the out-of-plane direction and across the van der Waals gap, as measured with conducting AFM (CAFM). The CAFM current maps and I-V characteristics are analyzed to estimate the MoS_2/GaN contact resistivity to be less than 4 Ω-cm^2 and current spreading in the MoS_2 monolayer to be approx. 1 μm in diameter. Epitaxial MoS_2/GaN heterostructures present a promising platform for the design of energy-efficient, high-speed vertical devices incorporating 2D layered materials with 3D semiconductors.

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