Doping Engineering through NH_3 Plasma Treatment for Threshold Voltage Control of MOCVD-Grown MoS_2 Thin-Film Transistor

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Abstract

Molybdenum disulfide (MoS_2) has been widely researched due to extraordinary properties such as atomically thin channel and high gate controllability, etc. However, the conventional doping method like ion implantation can give a large damage to the two-dimensional layer structure. In this study, we investigate a substitution nitrogen doping method with large area and uniformity through NH_3 plasma treatment. Since nitrogen acts as a p-type dopant for MoS_2, it causes a positive threshold voltage (V_{th}) shift. On the other hand, during the nitrogen doping, sulfur vacancies or compressive strain from Mo-N bonding cause negative V_{th} shift. In this paper, we can observe that nitrogen doping causes change of V_{th} both positive and negative shift under specific conditions. As a result, V_{th} changed by +1.72 V and -0.94 V, electron carrier density changed by $-3.4\times10^{11}cm^{-2}$ and $+4.2\times10^{11}cm^{-2}$, respectively.

References

[1] Azcatl, A., et al., Nano letters, 16 (2016), 5437-5443

Figures

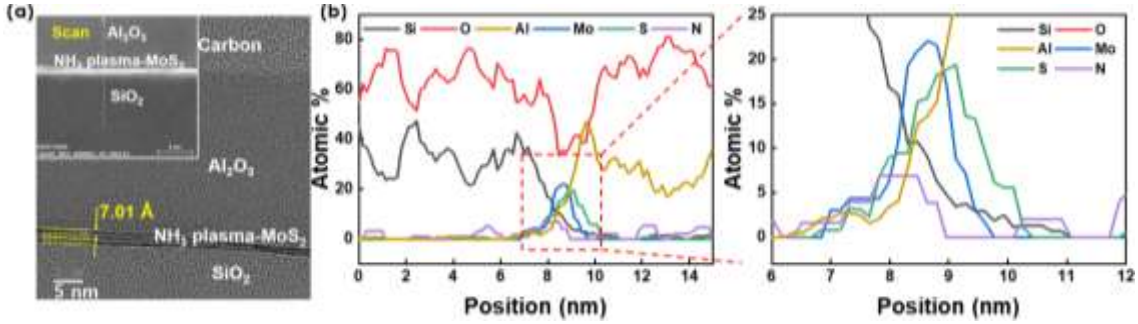

Figure 1: (a) TEM image of NH_3 plasma treatment multilayer MoS_2. (b) EDS line scanning profiles of nitrogen doped MoS_2

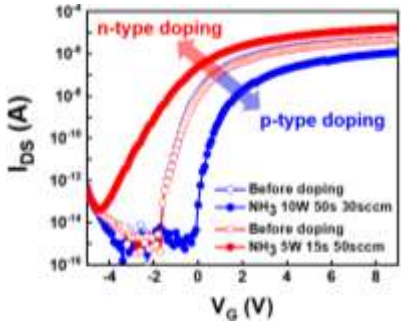

Figure 2: I-V characteristics of the nitrogen doped MoS_2 device showing bidirectional V_{th} shift.