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Carrier type modulation and mobility improvement of thin $MoTe_2$

Abstract
Two dimensional semiconducting transition metal dichalcogenides (TMDCs) have attracted enormous attention recently.[1-4] This work describes the first systematic modulation of the carrier type in $MoTe_2$. Unipolar p- and n-type $MoTe_2$ FETs with 10^5 and 10^6 on-off ratios were achieved by using rapid thermal annealing (RTA) and Benzyl Viologen (BV) doping respectively. $MoTe_2$ is ultra-sensitive to O_2 at elevated temperatures (250°C). $MoTe_2$ was annealed via rapid thermal annealing at various vacuum levels to tune the $MoTe_2$ charge carriers between predominantly pristine n-type ambipolar, symmetric ambipolar, unipolar p-type, and degenerate-like p-type. Changes in the $MoTe_2$ transistor performance were related to the physical and chemical absorption and dissociation of O_2, especially at tellurium vacancy sites. Benzyl viologen doping using optimized dopant concentrations and annealing conditions was used to achieve unipolar n-type $MoTe_2$ FETs with a high on-off ratio exceeding 10^6. The dopant concentration and annealing conditions were varied to modulate the electron concentration over a wide range. Furthermore, Al_2O_3 Capping was then introduced to the device surfaces for improving the carrier mobilities. Hole and electron mobilities were improved to 41 cm^2/Vs and 80 cm^2/Vs respectively after Al_2O_3 capping; they are among the highest carrier mobilities of $MoTe_2$ transistors ever obtained. A lateral homogeneous $MoTe_2$ p-n diode was fabricated combining the electron and hole doping techniques, the device displays excellent diode properties with a high rectification ratio of 10^4 at 0 gate bias and an ideality factor of 1.2.

References

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