Summary of VBL Research Project

Theme	Realization of $MoTe_2$-monolithic tunnel field effect transistor by utilizing noble laser irradiation technique
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In this study, in order to contribute a high speed operation in future flexible devices, we realize high performance tunnel-field effect transistors (TFETs) composed of transition metal dichalcogenide (TMDC). Different from conventional metal-oxide-semiconductor (MOS) FET, TFET is expected for high-performance operations such as low operation voltage, low power consumption, high-speed operation (low sub-threshold swing (SS)) due to the direct tunneling from the valence band in the p-type region to the conduction band in the n-type one. These performances can be expected superior to those in a conventional MOSFET. Therefore, two-dimensional materials such as TMDC is attracted for flexible TFET device applications due to its better flexibility than Si and higher mobility than organic semiconductors. However, a heavy doping condition close to a metallic behavior is not so easy in TMDC so far. Our group has been interested especially in $MoTe_2$ and we have found some of our original methods such as carrier density and polarity control, and Ohmic contact to metal electrodes by utilizing laser irradiation with various power density and environmental condition. Using these techniques, we try to write electrical circuits within a $MoTe_2$ crystal (Fig. 1). In our strategy, not using van der Waals hetero-junction in fashion, we try to realize monolithic electrical circuits which are used in Si-based large scale integrated circuits for a future practical application.

In this year, we plan to perform mainly three kinds of studies; "verification of carrier density distribution during the TFET operation", "improvement of SS value", "realization of p-type TFET and complementary-inverter device application". In TMDC, the impurity doping method must be completely different from conventional Si-process and then our laser doping techniques would have a potential of a venture-business chance in the realization of high-performance flexible devices used in the next generation technology. Also, such techniques may have a potential to change the text book of semiconductor devices in

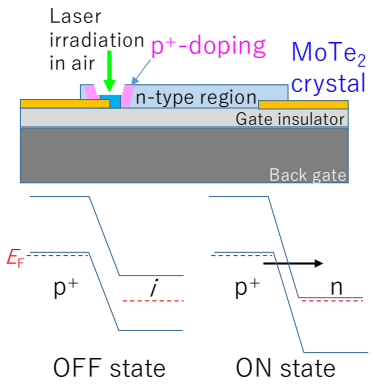

Fig. 1. Monolithic n-TFET structure fabricated by laser irradiation (top) and band structures in off- and on-states (bottom).

future.