I demonstrate herein that an electric field induced 2DEG provides unusually large enhancement of thermopower ($S$).[1] Field effect transistor structures were fabricated on a SrTiO$_3$ single crystal plate using water infiltrated nanoporous glass (CAN) as a gate insulator.[2] The CAN gate insulator can accumulate carrier electrons up to $\sim 10^{15}$ cm$^{-2}$, which is two orders of magnitude higher than that can be accumulated by conventional gate insulator such as SiO$_2$, Al$_2$O$_3$ and dry C12A7.[3] The thermopower $S$ values were measured by steady state method using the homemade equipment (Fig.) at room temperature. $|S|$ initially decreases with $n_{\text{sheet}}$ from $\sim 1150$ to $\sim 250$ $\mu$V K$^{-1}$. Simultaneously, effective thickness of the 2DEG ($t_{\text{eff}}$) decreases from $\sim 100$ to $\sim 2$ nm. In this region, the $n_{\text{sheet}}$ dependence of $|S|$ is similar to that of simulated bulk values. When the $n_{\text{sheet}}$ value exceeds $\sim 2.5 \times 10^{14}$ cm$^{-2}$, $|S|$ increases drastically and is modulated from $\sim 600$ ($n_{\text{sheet}} \sim 2 \times 10^{15}$ cm$^{-2}$) to $\sim 950$ $\mu$V K$^{-1}$ ($n_{\text{sheet}} \sim 8 \times 10^{14}$ cm$^{-2}$), while $t_{\text{eff}}$ remains nearly constant ($\sim 2$ nm). $|S|$ vs. log $n_{\text{sheet}}$ relation is approximately five times larger than that of the bulk, clearly indicating that the electric field induced 2DEG in SrTiO$_3$ exhibits an unusually large $|S|$. Moreover, because the present electric field thermopower modulation method is simple and effectively verifies the performance of thermoelectric materials, it may accelerate the development of nanostructures for high performance thermoelectric materials.

References