the gap δE gradually decreases with the increase of the width N, and beyond a certain value of N, the rate of decrease of this gap becomes much small and eventually it (δE) becomes almost a constant. Quite similar feature is also observed if we plot the variation of the energy gap as a function of the length M keeping the width N as a constant, and due to the obvious reason we do not plot these results further in the present description. These results provide us an important signature which concern with the variation of the energy gap by tuning the size of the ribbon, and we can emphasize that a honeycomb lattice ribbon with zigzag edges always exhibits the semiconducting (finite energy gap) behavior.

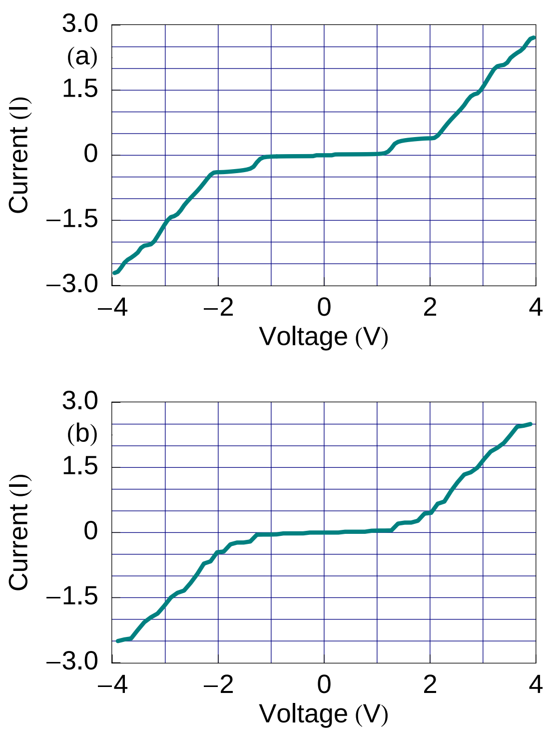

Figure 5: (Color online). Current I as a function of the bias voltage V for some lattice ribbons with fixed width $N = 3$ and varying lengths where (a) $M = 3$ and (b) $M = 6$.

All these basic features of electron transfer can be much more clearly explained from our investigation of the current-voltage (I-V) characteristics rather than the conductance-energy spectra. The current I is determined from the integration procedure of the transmission function (T) (see Eq. 8), where the function T varies exactly similar to the conductance spectra, differ only in magnitude by a factor 2, since the relation $g = 2T$ holds from the Landauer conductance formula (Eq. 1). As an illustration, in Fig. 5, we present the current-voltage (I-V) characteristics for some lattice ribbons with fixed width $N = 3$ and varying lengths where (a) and (b) correspond to the lengths $M = 3$ and 6 respectively. In the same footing, in Fig. 6, we plot the variation of the current I as a function of the bias voltage V for some typical lattice ribbons keeping the length as fixed ($M = 4$) and vary the widths, where (a) and (b) represent the ribbons with widths $N = 2$ and 3 respectively. The sharpness in the I-V characteristics and the current amplitude solely depend on the coupling strengths of the ribbon to the side attached electrodes, viz, source and drain. It is observed that, in the limit of weak coupling, defined by the condition $\tau_{S(D)} << t$, current shows staircase like structure with sharp steps. While, in the strong coupling limit, described by the condition $\tau_{S(D)} \sim t$, current varies quite continuously with the bias voltage V and achieves large current amplitude compared to the weak-coupling limit. All these coupling effects have already been explained

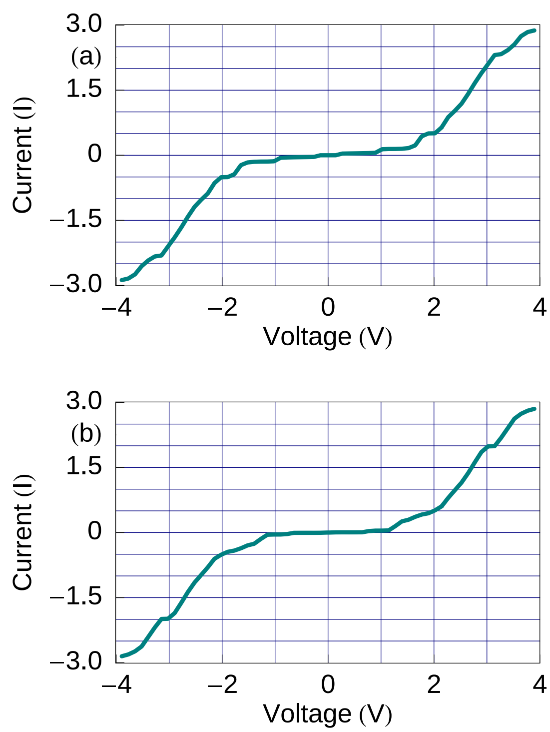

Figure 6: (Color online). Current I as a function of the bias voltage V for some lattice ribbons with fixed length $M = 4$ and varying widths where (a) $N = 2$ and (b) $N = 3$.