it coincides with the value of the current when a large reverse voltage is applied to the junction. It depends (in a very complex way) from the constructive parameters of the diode, such as the area and the depth of the junction, or the doping spatial uniformity. It is possible to put on a reasonable basis its main dependence on the temperature following the argument that I_S grows with the population of the conducting level of the semiconductor carriers and that this follows a stationary thermodynamic distribution, so that:

$$I_S = I_0 \exp\left(-\frac{E_G}{kT}\right) \tag{2}$$

where E_G is the energy gap of the bulk semiconductor.
Using a similar argument adopted normally to introduce the non-ideality factor n in the Shockley equation, the same factor must be taken into account in the exponential dependence of I_S:

$$I_S = I_0 \exp\left(-\frac{E_G}{nkT}\right) \tag{3}$$

Although in the real diode the value of n is only approximately constant with V, in a quite large interval of direct currents eq. (1) reproduce well the I–V curve with constant values of I_S and n, and these two parameters can be determined easily with some fitting procedure, even graphical. In fact, when $V \gg nV_T$, the logarithmic graph of the current show a clear initial linear trend. The dependence of the fitted value of n on the portion of the characteristic curve analyzed has been already discussed previously[12].

To increase the quality of the fit of experimental data, some authors [13] proposed junction models consisting of a sum of exponentials, each with different I_S and n parameters. Each contribution is considered valid in different region of the I–V curve and some kind of connection in the contiguous regions is required. The weakness of those strategies is the lack of an underlying simple physical picture and the increase of the number of model parameters.

Finally, it is easy to observe significant deviation from the behaviour predicted by the model of eq. (1) on both sides, of large and very low currents. In the first case the observed direct current is lower than that predicted by the model, and the exponential trend is weakened so that the logarithmic graph stay under the straight line calculated in the range of intermediate current. At the lowest current a larger direct current is observed with respect to that calculated with the parameter estimated in the region of intermediate currents. The origin of the large current deviation could be justified at an elementary level as the lowering of the voltage difference across the junction with respect to the applied *fem* due to ohmic voltage drop in the semiconductor bulk hosting the junction. On the other hand, the low current regime originates from the presence of alternative paths for the current. When the junction current is very low those parallel paths gives a comparable contribution to the total current with a different dependence on V which is rapidly overcome from the exponential term of the junction. Then, a more accurate model for the stationary I–V characteristic of the diode can be formulated introducing a series resistance R_s, accounting for the ohmic voltage drop across the semiconductor bulk, and a parallel resistance $R_p = 1/G$, accounting for alternative paths: Fig. (1) shows the equivalent electrical circuit; this model has four parameters, and eq. (1) modifies into:

$$I = I_p + I_J = GV + I_S\left[\exp B\left(V - R_s I_J\right) - 1\right] \tag{4}$$