Current–Voltage Characteristic of a *pn* Diode: a Benchmark for Laboratory Courses

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Abstract. We show that in a simple experiment at the undergraduate level, suitable to be performed in classes of science and engineering students, it is possible to test accurately, on a popular 1N4148 *p-n* diode, the range of the junction currents where the Shockley equation model can be considered satisfactory. The experiment benefits from a system of temperature control and data collection driven in a LabVIEW environment. With these tools a large quantity of data can be recorded in the temporal frame of a lab session. Significant deviations of the experimental *I–V* with respect to the ideal behaviour curve predicted by the Shockley equation are observed, both at low and high current. A better agreement in the entire range is obtained introducing, as is customary, a four parameters model, including a parallel and a series resistance. A new iterative fitting procedure is presented which treats the *I–V* data of different regimes on the same level, and allows a simultaneous determination of the four parameters for each temperature selected. The knowledge of the temperature dependence of the saturation current is used to estimate the energy gap of silicon. The connection of a macroscopic measure with a microscopic quantity is another valuable feature of the experiment from an educational point of view.

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1. Introduction

Current-Voltage (*I–V*) curves are used routinely to give a synthetic graphical information of non-ohmic electronic devices such as semiconductor diodes. Moreover, a lot of information about the properties of conducting materials and devices is obtained through the analysis of the current-voltage dependence both in DC and in AC regimes. In the literature there is a large amount of *I–V* based studies for a wide variety of devices, encompassing homogeneous, composite materials and even biological structures.

It is worth mentioning that *I–V* characteristic measurements are used for the assessment of the performances of conventional photovoltaic cell[1] and non conventional photodevices such as a single carbon nanotube exhibiting the peculiar