What Do Solid State Devices Actually Do?

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Robert J. Scoff, P.E.

Table of Contents

List of Illustrations

1. Introduction

In our modern world, there are many Solid State devices that work for us on a daily basis. To help us navigate this modern Solid State world, I believe that it would be useful to know what these devices actually do. We do not need to know or understand, solid state physics to know what devices actually do. This course is written so that anyone can see and feel what these devices do. With that in mind, let's look at some solid state devices and start to see how easy it is to understand what the devices of our modern world actually do.

2. Wires

This might be a strange place to start on Solid State Devices. But we start with wires because they are actual devices. They are solid, have some resistance, and for alternating current, they may have some inductance and/or capacitance. A simple model of a piece of wire for direct current flow is shown in Figure 2.1.

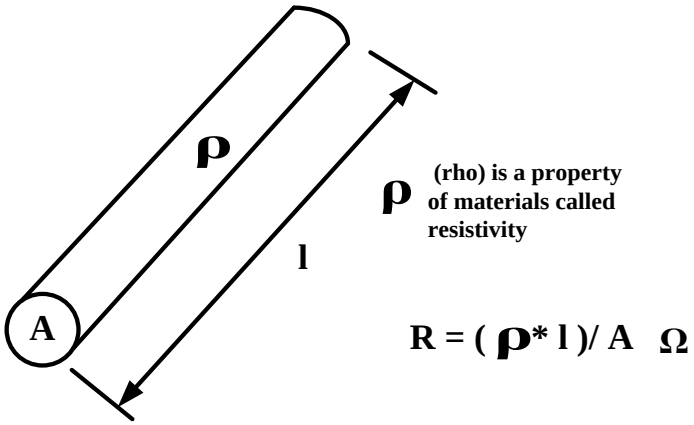

Figure 2.1 Model for a Piece of Wire

The drawing shows that the resistance (R) of the wire depends on its cross-section area (A), its length (l), and its resistivity (ρ). The unit of resistance is Ohms (Ω). In the English System, ρ has the units of Ohm-Circular Mills per foot, Area has the units of Circular Mills (CM), and length has the units of feet. A Circular Mill is the area of a circle with a diameter of 0.001 inches. Admittedly, this is odd, but the English System developed this way and did have some

odd features. Figure 2.2 gives an idea of a way to look at the area in Circular Mills of two circles with diameters of 0.001 inches and 0.002 inches.

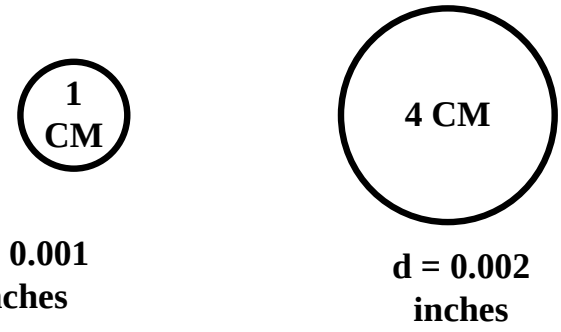

Figure 2.2 Drawing Showing How to Think about Circular Mills

The Area in CM of a circle is found by the following formulas:

Area in CM = d^2 (in inches) / 0.001^2 (in inches) or

Area in CM = d (in mils)^2 where 1 mil is 0.001 inch

In the Metric System, the Area is usually given in square meters. Sometimes, square millimeters are used. To keep things simple, for our work here, we will only use square meters.

The resistivity (ρ) is a property of materials. It is low for conductors like copper and other metals, and high for insulators like most plastics and Teflon. As mentioned earlier, in the English system of units, ρ has the units of Ohm-CM per foot. In the Metric System, ρ has units of Ohm meters^2 per meter. Sometimes this is shortened to Ohmmeters. This could lead to confusion, so we will always use Ohm-meters^2 per meter. Figure 2.3 is a chart showing the resistivity of some materials at 20 degrees centigrade (68 degrees Fahrenheit). The Temperature Coefficient of Resistance is also given in the chart. We need to know this because resistance actually changes with temperature and depends on the Temperature Coefficient (α) of the material.

Material	Resistivity (ρ) in Ohm-CM per foot	Resistivity (ρ) in Ohm-Meter^2 per meter	Temperature Coefficient (α) in Degrees Centigrade
Aluminum	15.93	$2.65*10^{-8}$	0.0043
Copper	10.37	$1.725*10^{-8}$	0.0040
Lead	123.84	$20.6*10^{-8}$	0.0039
Silver	9.558	$1.59*10^{-8}$	0.0038
Tin	66.128	$66.128*10^{-8}$	0.0045
Zinc	36.42	$5.90*10^{-8}$	0.0038
Nickel	43.15	$6.99*10^{-8}$	0.0059
Iron	59.94	$9.71*10^{-8}$	0.0057
Germanium	$28.39*10^{7}$	$4.60*10^{-1}$	-0.0480
Silicon	$39.5*10^{10}$	$6.4*10^{2}$	-0.0750
Wood	$6.17*10^{23}$	$1*10^{15}$	Not Applicable
Hard Rubber	$6.17*10^{21}$	$1*10^{13}$	Not Applicable
Fused Quartz	$46.29*10^{25}$	$7.5*10^{17}$	Not Applicable
Teflon	$\sim 1*10^{32}$		ot Applicable

Figure 2.3 Chart o f the resistance of Some

Copper, aluminum, an nonly used conductors. Silver has the lowest re n special places where silver has been used as se silver is a lot more expensive than copper. ed as the electrical conductor was (and may often referred to as semi-conductors, and the conductors and lower than the typical ins e, which means that the resistance drops with used as the model for a piece of wire. Figure 2.4 shows and a model of that piece of wire, which is simply a