

Excel Electron Range Approximation Tool

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1 Overview

This document provides documentation and instruction for the Microsoft Excel electron range tool developed by USU's Materials Physics Group. The model used is described in [Wilson, 2010;Starley, 2016].

2 Microsoft Excel Sheet

The worksheet is organized into several tabs including the *Information*, *Graphs and Data*, *Custom Material*, *Material Data*, *Range Calculation*, and *IMFP Calculation* tabs. All user-customizable fields are denoted with an orange fill, as shown in Figs. 1 and 2. Cells without orange fill should not be changed without a clear understanding of inner workings of the worksheet.

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2.1 Information Tab

The *Information* tab acts as a front end to the worksheet with links to information on how to use the worksheet, the theoretical basis for the model and its development, and supporting references for this and related range models.

2.2 Graphs and Data Tab

The *Graphs and Data* tab (Fig. 1) is main worksheet where user interaction occurs. This tab includes three drop-down lists where three different materials can be selected. Below each drop-down list is a check box which turns the data export for each material on or off. The material properties are then displayed in a table to the right, as shown in Fig. 1(b). The range data are presented in two formats which can be copied and pasted into other applications for further use by the user: (i) a tabular format and (ii) a graphical format (When pasting the graph into another *Microsoft* program, use the *Picture* option.).

Any formatting properties of the graph can be readily changed according to user preferences using *Excel* options. The energy range for calculations and plotting can also be customized by editing the values in cells B8 and D8, which will automatically adjust the graph axes to fit the data. The *Log Energy* checkbox in cell E8. automatically changes the graph between a Log-Log plot and a Linear-Linear plot and changes the spacing of the 200 energy values calculated from linear to logarithmic.

2.3 Custom Material Tab

The *Custom Material* tab is used to input custom material properties and determine the number-weighted Mean Atomic, \bar{Z} , and Average Atomic Weight, \bar{M} , for up to 10 custom materials. \bar{Z} and \bar{M} are calculated for a custom material by entering the number of atoms of each element (rows 6 to 108) from the material's chemical formula. For example, in column D of Fig. 2, sodium chloride (NaCl) is entered as a custom material, with the name in cell D1, the chemical formula in cell D2, the mass density in cell D3, the bandgap in cell D4, and 1 in cells D16 and D22 for Na and Cl respectively. Cells D119 and D120 list the calculated values of 14 for \bar{Z} and 29.22 for \bar{M} .

Calculations and plots for custom material can then be selected from one of the three drop-down boxes in the *Graphs and Data* tab. Note, the custom materials are found at the bottom of the list and not in alphabetical order. Values for the relative number of atoms for a material can also be entered as percentages; see an example for tin-rich indium-tin oxide (ITO) in column G of Fig. 2. Specific isotopes of elements (rows 109-115 for deuterium (D), tritium (T), He^3 , C^{13} , C^{14} , N^{15} , O^{18} and rows 116 to 117 for two isotopes) with user-defined atomic numbers and atomic weights can also be selected for custom materials; see an example for partially deuterated polyimide [$\text{C}_{22}\text{H}_5\text{D}_5\text{N}_2\text{O}_5$]_n in column E of Fig. 2.

2.4 Material Data Tab

The *Material Data* tab includes a table which lists all of the 246 materials for which N_v^{eff} has been determined from fits to the NIST databases, along with the required material properties and parameters for the model. At the bottom of the material list is a set of 10 rows for custom materials carried over from the *Custom Material* tab along with their material properties, fitting constants, and model parameters. Columns H through R shows calculated values for intermediate model values

3 References

Gregory Wilson and JR Dennison, "Electron Range Computational Tool for Arbitrary Materials over a Wide Energy Range," 15th Spacecraft Charging Technology Conference, Kobe University, (Kobe, Japan, June 25-29, 2018).

Anne Starley, Gregory Wilson, Lisa Phillipps and JR Dennison, "Predictive Formula for Electron Penetration Depth of Diverse Materials over Large Energy Ranges," Proceedings of the 14th Spacecraft Charging Technology Conference, Space Research and Technology Centre of the European Space Agency (ESA/ESTEC), (Noordwijk, Netherlands, April 4-8, 2016), 2 pp.





Gregory Wilson and JR Dennison, "Approximation of Range in Materials as a Function of Incident Electron Energy," Proceedings of the 11th Spacecraft Charging Technology Conference, (Albuquerque, NM, September 20-24, 2010), 6 pp.