ME 595M

Computational Methods for Nanoscale Thermal Transport

BTE Assignment

Due June 4, 2007

Consider the solution of the gray BTE in a thin slab of silicon, as shown below. The left and right boundaries are given temperature, with T_{left} = 310 K and T_{right} = 300K. The top and bottom boundaries are specular. The length of the domain is L and the aspect ratio of the domain is L/H = 10. Use 50 control volumes in the x direction and 11 control volumes in the y direction. Use the following properties for silicon: v_g = 6400 m/s, C=1.631x10^6 J/m^{3}K, τ_{eff} = 7.2 ps. Use the class code to do the assignment.

(a) Compute the "temperature" field in the domain for acoustic thicknesses $L/(v_g\tau_{eff})$ = 0.01, 0.1,1,10,100. One way to do this is to vary L and H while maintaining L/H =10. You can set the top and bottom boundaries to be specular by setting the variable *ldiffuse* to *false* in subroutine *grid*.

(b) Record the number of iterations to convergence for each case. You may define convergence using any reasonable standard. One such standard is that a typical temperature in the domain stops changing much with iteration. Comment on what happens to the convergence rate as the acoustic thickness increases and why.

(c) Plot the dimensionless temperature $(T-T_{right})/(T_{left}-T_{right})$ versus x/L along the horizontal centerline in each case. The exact solution is provided for first 4 acoustic thicknesses for comparison from the solution of Heaslett and Warming for participating radiation between parallel plates (Modest, Radiative Heat Transfer, 1993). Comment on the temperature variation you obtain for the different acoustic thicknesses.

(d) Now consider the case when the top and bottom boundaries are diffuse reflectors. Turn on the diffuse reflection boundary condition by setting the variable *ldiffuse* to be true and repeat parts (a)-(c). Comment on the temperature solutions you obtain at the same acoustic thickness with the two different types of boundary conditions.