Temperature Distribution in a HFCVD Reactor

Renata Sampaio da Rocha[1], Jerônimo dos Santos Travelho[1]
[1]Laboratory for Computing and Applied Mathematics - LAC
Brazilian National Institute for Space Research - INPE
C. Postal 515 – 12245-970 – São José dos Campos - SP
BRAZIL
E-mail: renata@lac.inpe.br., jeff@lac.inpe.br

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This work shows a two dimensional numeric scheme implementation in order to obtain the temperature profile in a reactor during the process of diamond growing with CVD (chemical vapor deposition) assisted by a hot filament.
Due to its strong chemical bond, the diamond has special properties: high mechanical strength, high thermal conductivity and low coefficient of friction that allow its application in many technological areas like the protection of solar cells and surfaces exposed to particles bombarding, heat dissipater and electronic equipments.
Because of the variety of possible applications, the DIMARE group of INPE - Brazilian National Institute for Space Research - is doing research on this material. To understand the growth and the possible applications of this diamond film, lot of research was already done.
The reactor of diamond HFCVD used in LAS/INPE is constituted of a Pyrex tube with 60mm of diameter and 250mm of length.
The temperature of the substrate and filament were maintained at 1000K and 2500K respectively. The operating pressure was $4.0.10^3$ Pa (30 Torr) and the walls were maintained at the temperature 330K. The gas flow rate is $\simeq 100 cm^3 \ \mathrm{min}^{-1}$.
The modeling of the two dimensional diffusion equation in a cell-centered scheme with unstructured triangular grid is done with ABC (Circumcenter Based Approach). The circumcenter is used to calculate the variables, in this case, temperature. The Finite Volume Method was used to discretize the heat diffusion equation. The unstructured mesh was chosen due to its easy adaptation to the complex configuration of the reactor.
The mathematical model can be described by the governing partial differential equation, i.e., the equation of heat conservation. Considering just the diffusion of heat in the stationary case, the heat transport equation becomes:

$$\nabla.(\Gamma \nabla T) = 0 \qquad (1)$$

Where: Γ is the diffusion coefficient.
For the triangular element shown in Figure 1, the equation (1) discretized, may be written as follow:

$$A_p T_p = A_a T_{VA} + A_b T_{VB} + A_c T_{VC} \qquad (2)$$

Where:

$$A_a = \frac{S_a \Gamma_{sa}}{Dist_{P-VA}}, \ A_b = \frac{S_b \Gamma_{sb}}{Dist_{P-VB}}, \ A_c = \frac{S_c \Gamma_{sc}}{Dist_{P-VC}} \quad ,$$

$$A_p = A_a + A_b + A_c$$

and T_{VA} , T_{VB} and T_{VC} are the temperatures in the neighbors circumcenters VA , VB and VC respectively.

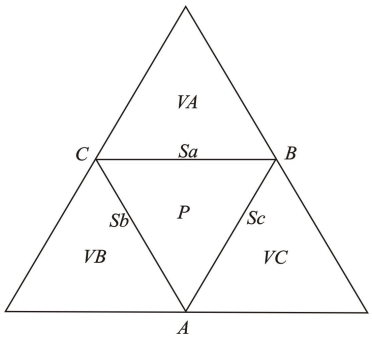

Figure 1: Triangular element used in the discretization.

From the simulation is possible to obtain the profile temperature and compare it with experimental results of DebRoy et al (1990) with a good agreement.

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