CONTROL OF SUBSTRATE TEMPERATURE DURING DIAMOND DEPOSITION

M. T. Bieberich* and S. L. Girshick

Department of Mechanical Engineering
University of Minnesota, Minneapolis, MN 55455, USA
*Presently at Thomas & Betts Corp., Memphis, TN

Abstract

A method for actively controlling substrate temperature during high heat flux diamond deposition is described. The method is a modified version of the approach developed by Thorpe *et al.*,[1] in which substrate temperature is varied by varying the composition of an argon-helium mixture which flows through small channels beneath the substrate. By using a simple one-dimensional model we show that the substrate temperature is controlled not by the channel flow but rather by the thermal contact resistance between the substrate and the surface on which it rests. Control over the contact resistance arises from the much higher thermal conductivity of helium compared to argon.

Experimental trials of the temperature control system in an atmospheric-pressure RF plasma reactor under diamond CVD conditions verified the main features of the simple model. For the conditions tested the substrate temperature could be varied by over 600 K by adjusting the argon-helium proportions, with a close-to-linear response in which substrate temperature increased by 7.3 K for each one percent increase in argon mole fraction. The temperature was found to be unaffected by the argon-helium flow rate or by the number of channels. The time for the substrate temperature to respond to a change in mixture composition was found to be on the order of one minute.

The control system includes a temperature measurement of the back side of the substrate by means of an optical fiber interfaced to a single-color pyrometer. It is suggested that this is a more reliable basis for temperature control than a measurement of the growth surface itself, because of the changing emissivity of the surface during film growth.

[1]T. P. Thorpe, K. A. Snail, R. G. Vardiman, and T. Smith, *Proc. 3rd Intl. Symp. Diamond Mater.*, Honolulu, May 1993, edited by J. Dismukes and K. Ravi, Electrochemical Society vol. 93-17.