Determination of the Optical Functions of Carbon-Based Materials Using Transmittance, Reflectance and Spectroscopic Ellipsometry—A Critical Review—

Juan Antonio Zapien* and Robert Warren Collins1

Department of Physics and Materials Science, and Center of Super-Diamond and Advanced Films (COSDAF), City University of Hong Kong, Hong Kong
1Department of Physics and Materials Research Institute, The Pennsylvania State University, University Park, PA 16802, USA

(Received 5 June 2003; accepted 1 July 2003)

Key words: optical function, ellipsometry, transmission and reflection, tetrahedral bonding, carbon based materials

The perception that the optical characterization of carbon-based materials is of limited use is not uncommon. As evidence of this perception, most review articles and book chapters devote little attention to the details of determination of the optical functions for carbon-based materials. It is ironic, however, that the same reviews provide ample evidence of useful correlations between the indices of refraction and deposition parameters and/or basic film characteristics. In fact, the complications in the optical characterization of carbon-based materials require greater attention. These complications arise from (1) the great diversity of carbon-based materials that can be prepared with relatively small changes in deposition conditions, in combination with (2) a number of nonidealities and inhomogeneities that may occur in such films including, for example, (i) high sp2 content top surface layers; (ii) graphite-like inclusions; and (iii) layered structures. Although steady progress has been made in the measurement and modeling of the optical properties of carbon-based thin films, such efforts have yet to make major impacts in this field of research. In this contribution, we discuss the current state of research on the optical characterization of carbon-based materials, and place it in perspective relative to the state-of-the-art optical characterization of thin films in general. With this aim, we provide a critical review of selected case studies of carbon-based materials that have been chosen as illustrative examples of the different optical characterization techniques available, the insights they provide, and the future directions suggested.

*Corresponding author: e-mail: apjazs@cityu.edu.hk