Dynamics of Photogenerated Carriers at the Boron-Doped Diamond/Electrolyte Interface

Ichizo Yagi, Kentaro Tsunozaki, Donald A. Tryk, and Akira Fujishima*

Department of Applied Chemistry, School of Engineering, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan

Boron-doped diamond thin film has emerged as an attractive new electrode material because of its unique electrochemical properties, for example, small background current, wide potential window, and good response to redox species. These features result from the fully covalent bonding of sp^3 type carbon and the stable chemical termination by hydrogen or oxygen atoms at the diamond surface. The as-deposited diamond surface is hydrogen-terminated, because the films are grown under a hydrogen plasma or in a hydrogen atmosphere. However, the oxygen-terminated surface can be formed by exposing the surface to an oxygen plasma or boiling in strong oxidizing acids. Anodic polarization in electrolyte solution can also introduce oxygen species at diamond surfaces. Recently, the change of the chemical termination, especially oxygen termination, has been shown to affect the electrochemical properties of the diamond electrode.

In this study, the photoelectrochemical response of boron-doped diamond electrode/electrolyte interfaces was examined to establish the influence of the chemical termination at the diamond surface on the dynamics of photogenerated carriers. Photocurrent transients were observed by a digital oscilloscope via a potentiostat. Photocurrent transients resulting from pulsed excimer laser irradiation at hydrogen-terminated (as-deposited) diamond electrodes and at oxygen-terminated electrodes, which were prepared either by exposing the surface to oxygen plasma or by anodic polarization in an electrolyte solution, were compared (Figure 2). A significant difference between the photocarrier dynamics for these two surfaces was observed in terms of the full-width-at-half-maximum (FWHM) of the photocurrent transients. The much faster decay observed for the oxygen-terminated surface is attributed to the depassivation of deep trapping sites due to removal of subsurface hydrogen.

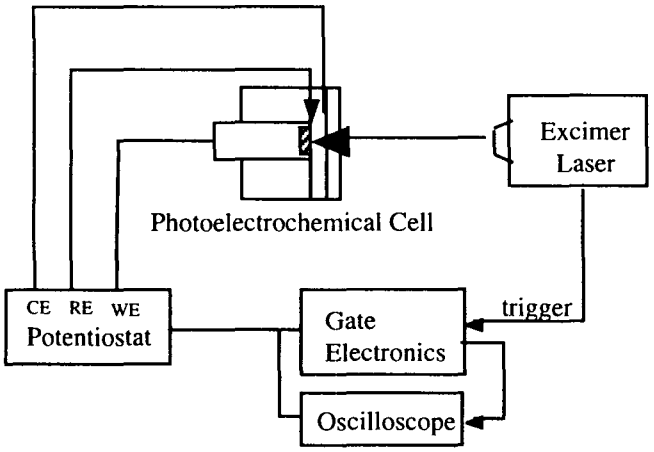

Figure 1. Experimental setup for laser pulse induced photocurrent transient measurement.

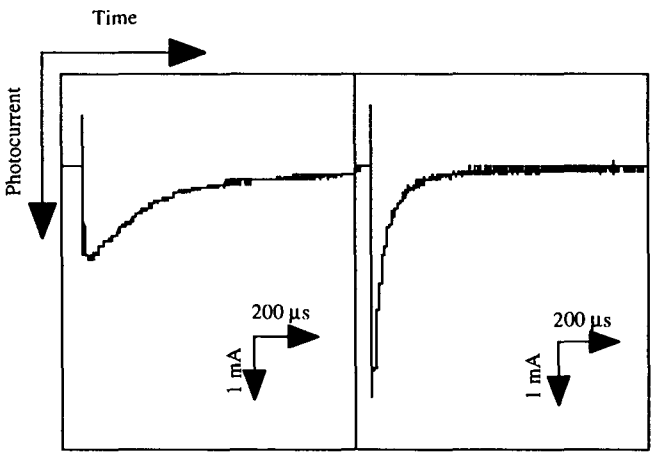

Figure 2. Photocurrent transients obtained at (a) as-deposited and (b) oxygen-terminated diamond electrodes