반도체 산업용 나노기공 함유 유기실리카 박막

차국헌, 윤도영[1], 이진규[1], 이희우[2]
서울대학교 응용화학부 고분자박막연구실
[1]서울대학교 화학부, 2서강대학교 화학공학과
(E-mail: khchar@plaza.snu.ac.kr)

It is generally accepted that ultra low dielectric interlayer dielectric materials ($k < 2.2$) will be necessary for ULSI advanced microelectronic devices after 2003, according to the International Technology Roadmap for Semiconductors (ITRS) 2000. A continuous reduction of dielectric constant is believed to be possible only by incorporating nanopores filled with air ($k = 1.0$) into electrically insulating matrices such as poly(methyl silsesquioxane) (PMSSQ). The nanoporous low dielectric films should have excellent material properties to survive severe mechanical stress conditions imposed during the advanced semiconductor processes such as chemical mechanical planarization process and multilayer fabrication. When air is incorporated into the films for lowering k, their mechanical strength has inevitably to be sacrificed. To minimize this effect, the nanopores are controlled to exist in the film as closed cells. The micromechanical properties of the nanoporous thin films are considered more seriously than ever, particularly for ultra low dielectric applications.

In this study, three approaches were made to design and develop nanoporous low dielectric films with improved micromechanical properties: 1) wall density increase of nanoporous organosilicate film by copolymerization of carbon bridged comonomers; 2) incorporation of sacrificial phases with good miscibility; 3) selective surface modification by plasma treatment. Nanoporous low-k films were prepared with copolymerized PMSSQ and star-shaped sacrificial organic molecules, both of which were synthesized to control molecular weight and functionality. The nanoporous structures of the films were observed using field emission scanning electron microscopy, cross-sectional transmission electron microscopy, atomic force microscopy, and positronium annihilation lifetime spectroscopy (PALS). Micromechanical characterization was performed using a nanoindentor to measure hardness and modulus of the films.