

Seminar Announcement

Department of Materials Science and Engineering

National Chiao Tung University

Hosted by Prof. Jihperng (Jim) Leu

Time: 10:00 – 11:00 AM, November 7, 2016

Place: Room 324, Engineering Building No. 6

Speaker: Dr. Mikhail R. Baklanov, Jiangsu Leuven Instruments

Visiting Professor, North China University of Technology

Topic: Ultra low-k insulating materials for advanced nanoelectronics

Materials with low dielectric constant (low-k) have been introduced into ULSI technology starting from early 1990th because of the need to increase the operation speed of integrated circuits, to decrease the dynamic power consumption, and cross-talk noise in IC interconnects.

The low k-value is achieved by decreasing the polarizability of chemical bonds and density. Early generations of low-k dielectrics with $k = 3\text{--}3.5$ were obtained by doping the traditional SiO_2 with fluorine and carbon during plasma-enhanced chemical vapor deposition (PECVD). Other types of low-k dielectrics were based on organic polymers. Low polarizability of chemical bonds in organic low-k films allowed to achieve the k-values 2.6–3.0 without introduction of porosity. Their integration, however was very difficult because of a high coefficient of thermal expansion in comparison with other IC components. Most of presently used low-k materials are based on porous organosilicate glasses (OSG). They are deposited by PECVD and spin-on glass technology (SOG). Usually, these films have SiO_2 -like matrix but parts of Si bonds are terminated by $-\text{CH}_3$ groups. Highly porous OSG are prepared by using sacrificial porogens (organic polymers) co-deposited together with silica-like matrix material. The sacrificial porogens is removed after deposition. The complete porogen removal can be difficult sometimes and the remaining residue (sp^2 carbon) degrades the electrical characteristics: increases the leakage current and decreases the breakdown field. A dramatic increase in the pore size and their connectivity is observed when the k-value of OSG materials is becoming smaller than 2.5. The plasma species (F, O,...) species break Si-CH_3 and $\text{Si-CH}_2\text{-Si}$ bonds in OSG matrix and make them hydrophilic, which is not acceptable for low-k materials because of a high dielectric constant of adsorbed water molecules. Similar degradation of low-k matrix can also be related to VUV light generated in the etch plasma, which also reduces the concentration of CH_3 groups. VUV effects depend on wavelength and also increase with porosity.

This presentation will give an introduction to imec, overview of existing low-k materials, features of their modification during the different integration steps, new approaches allowing their integration. At the end, some properties and the challenges of future ultra low-k candidates and innovative solutions for their integration will be discussed.

A discussion session will be followed at 11-12 am.