Combining nanoindentation with complementary techniques for mechanical and structural characterization of ultra low-k (ULK) thin films

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Nano-porous dielectrics used as insulating materials between on-chip interconnects are an important component in metallization stacks of leading-edge microelectronic products to reduce electrical signal delay and power loss. The main drawbacks of these porous dielectrics are their weak mechanical properties. Therefore, new types of porous organosilicate glasses (OSGs) exhibiting a pore arrangement with a high degree of intermittency were developed to improve their mechanical properties. In this study, we will show the relationship between porosity, pore topology, and elastic modulus based on simulations as well as experimental studies using several OSG films. The main part of this study are the experimental techniques used for mechanical and structural analysis of the OSGs. Mechanical characterization is done using nanoindentation (NI) and is complemented by atomic force acoustic microscopy (AFAM), see Figure 1, as well as surface acoustic wave (SAW) measurements. Hereby, the possibilities and limits of measuring surface gradients in the mechanical properties of thin OSG films using these techniques will be discussed. The structural properties are assessed using positron annihilation lifetime spectroscopy (PALS) and transmission electron microscopy (TEM).

Figure 1 – Measurement of a surface gradient in the Young's modulus of a thin ULK film using nanoindentation and AFAM in different force ranges.