A design of low-κ and stiff silica aerogel for interlayer dielectric in semiconductor device

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Abstract

RC delay, power dissipation and crosstalk have occurred as semiconductor device has been miniaturized and integrated in nanoscale. To alleviate these problems, material that has very low dielectric constant (ultimate low-κ) should be used for interlayer dielectric of nanoscale semiconductor devices. Silica aerogel, a porous material composed of silica and air, can be used as the interlayer dielectric material to achieve ultimate low-κ. However, the problem due to its low stiffness needs to be solved for endurance required in planarization. The purpose of this study is to discover the geometric effects on electrical and mechanical properties of silica aerogel and provide the direction for design of ultimate low-κ dielectric. In this study, the effects of various geometric parameters on dielectric constant and elastic modulus were analyzed using finite element method. In addition, the generalized formula was derived to predict the elastic modulus of pore structure. The results suggested that the porosity of silica aerogel is the main parameter that decides the dielectric constant and should be 0.76 to have very low dielectric constant of 1.5. Additionally, while maintaining the porosity of 0.76, the silica aerogel needs to be designed in ordered open pores structure (OOPS) containing 64 or more pores, positioned in simple cubic lattice points, to endure in planarization which requires the elastic modulus of 8 GPa to prevent delamination.

Keywords: interlayer dielectric, silica aerogel, dielectric constant, elastic modulus, pore structure

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