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NEC Develops New Full Low-k Cu-interconnect Structure

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NEC have developed a new Silica-Carbon Composite (SCC) film capable of blocking Cu-atom diffusion into the dielectric films of LSI interconnects. Use of the SCC film establishes an ultimate full-low-k (FLK) Cu interconnect structure that realizes a reduction in active power consumption in LSI interconnects.

The successful development of this FLK Cu interconnect can be attributed to extensive research and development on molecular nanotechnology manipulating the molecular structure and novel plasma-enhanced deposition technology.

Main features of the newly developed FLK interconnect:

(1) The new low-k barrier dielectric SCC film has been developed based on molecular nanotechnology, which has a composite structure of unsaturated C=C molecular bonds and the conventional silica backbone structure to prevent Cu diffusion into the interlayer dielectric (ILD) films. The dielectric constant (k) was decreased to 35% that of conventional barrier dielectrics.

(2) A special stabilization process of the Cu metal surface proved that the SCC film capping the Cu lines maintained excellent insulation reliability, even after reducing the film thickness down to several tens of a nanometer.

(3) All of the parts of the insulating film in the FLK Cu interconnect

consisted of low-k films, of which robust Molecular-Pore-Stack (MPS) low-k film with stable sub-nanometer-sized pores was deposited continuously on the SCC film on top of the underlying Cu lines.

(4) Parasitic capacitance as a source of active power consumption in the LSI interconnects was reduced by 11% as compared to the reference low-k Cu interconnects without SCC film, and reliability was improved.

The newly developed FLK Cu interconnect has an ultimate structure making it applicable not only to leading-edge 32nm-node CMOS devices, but also to all kinds of conventional CMOS devices to realize low power consumption and high reliability. CMOS LSI devices with FLK Cu interconnects are expected to realize high performance IT/network equipment with very low power consumption, such as broadband wireless terminal devices, high speed and multi-task servers and low power microcomputers for automobile applications.

As a result of device scaling, a rapid increase in parasitic capacitance among closely-spaced multilayer interconnects induces undesirable active power consumption. Therefore, a solution to suppress parasitic capacitance has been long sought after. LSI multi-level Cu interconnects are isolated by two kinds of dielectric film, such as the interlayer dielectric (ILD) films isolating the Cu lines themselves and the barrier dielectric films that directly cover the Cu lines to prevent diffusion of Cu atoms into the ILD films.

Extensive research and development has been carried out to establish low-k ILD films such as porous materials. However, it has been difficult for barrier dielectrics to fulfill both the requirements of low k-value and perfect blocking properties because the latter property is usually diminished by reducing the k-value or essentially the film density.

The newly-developed low-k SCC film blocks migration of the Cu atoms,

where its blocking mechanism is likely to be the capture of Cu atoms by the unsaturated carbon bonds in the SCC film. The FLK Cu interconnect features a seamless stack of MPS ILD film and SCC barrier dielectrics on the Cu lines, which are desired for low power and high speed signal processing in ubiquitous-network applications.

Source: NEC

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