Development of ultra low-k material and interconnect process for next generation memory devices

Mechanical strength of film doubled at k=2.4, thermal stability raised to 800℃, and interconnect process simplified

Tokyo, 13th June 2006 --- Hitachi, Ltd. (NYSE: HIT / TSE: 6501) and Hitachi Chemical Co., Ltd. (TSE: 4217) today announced that they have developed an ultra low dielectric constant spin-on glass (ultra low-k SOG) with a dielectric constant of k=2.4 and an interconnect (wiring) process, required for sub-50nm memory device fabrication. As a result of these developments, the mechanical strength of the low-k SOG was doubled in comparison to conventional SOGs; thermal stability was greatly increased to 800℃, and the interconnect process was simplified. These developments will contribute to both increasing the performance, as well as decreasing the costs of next-generation memory devices.

Memory devices, such as flash memories and dynamic random access memories (DRAMs), have rapidly increased their storage capacity and cost effectiveness by decreasing critical dimensions. A trade-off in this miniaturization is the increase in parasitic capacitance between memory cells or interconnects, which results in signal delay and high power consumption. Thus, low-k interlayer dielectric films which reduce this parasitic capacitance are considered indispensable in next-generation memory devices with minimum dimensions below 50nm. In general however, simply reducing the dielectric constant leads to decreases in film strength and thermal stability, and gives rise to the need for complicated and expensive processes to overcome these drawbacks. Hitachi and Hitachi Chemical have been involved in the development of low-k SOG (k=2.9) and related processes, however in order to achieve the “ultra” low-k film required in next-generation memory devices, it was considered necessary to approach the issue from both the material and process perspective.

In response to this challenge, Hitachi and Hitachi Chemical have jointly developed a new SOG which provides a low-k film with high mechanical strength and thermal

stability, as well as a low-cost interconnect process, for sub-50nm memory devices. Features of the technology are as follows:

(1) SOG with high planarity, thermal stability and mechanical strength
Interlayer dielectric film in memory devices are required to have high planarity for managing the overall planarity of the hierarchical structure of the devices. To obtain this high planarity, a SOG type insulating material is widely used, where the liquid material is coated on the uneven surface of the substrate to planarize the gaps and thermally cured to provide a hard solid film. While a planar surface is obtained just after coating, the thermal cure causes significant material shrinkage, leading again to an uneven surface. Therefore, a “re-flowable” SOG is commonly used as its flexible molecular structure allows the material to re-flow to re-planarize during thermal cure. The flexible molecular structure, however, reduces the thermal stability and the mechanical strength of the film. To overcome these issues, a new ultra low-k SOG with suppressed shrinkage and a rigid molecular structure has been developed. Features of the new SOG are a low dielectric constant of k=2.4, high planarity, double the mechanical strength of conventional SOG, high thermal stability of up to 800℃, and high chemical stability, as well. The new SOG can be used not only as an interlayer dielectric between interconnects but also between memory cells which require a high temperature fabrication process.

(2) Simplification of the interconnect process
In the conventional interconnect process, photo-lithography and dry etching are used create via-holes in the interlayer dielectric film to connect the wires, after which the photo-resist layer is removed using an oxygen plasma ashing and wet cleaning. By optimizing the etching condition to create via-holes and also taking advantage of the high chemical stability of the new ultra low-k SOG film a new process was developed which requires only an amine solution to remove the photo-resist. With this method, degradation of the SOG film which occurs during oxygen plasma ashing is avoided, increasing the reliability of the wiring. Further, as the process steps are reduced without the need for new equipment or chemicals, the overall cost of the interconnect process is reduced. The effectiveness of this method has been verified in interconnect prototypes for the 50nm generation.

The technology developed will be applied to Hitachi Chemical’s "HSG series", spin-on type low-k SOGs (k=2.4-3.0), for interconnect process beyond sub 50-nm memory devices. These results is presented at the 2006 Symposium on VLSI Technology, to be

held in Honolulu, Hawaii, U.S.A., from 13th - 15th June 2006.

■ Technical Terms:

(*1) Parasitic capacitance: Capacitance resulting from neighboring interconnects and the interlayer dielectric films in between, acting as a condenser. Parasitic capacitance increases as the distance between interconnects decrease.

(*2) Dielectric constant or static permittivity: a feature of the insulating material. It is determined by how the atoms or molecules within a material respond when an electric field is applied across it. The lower the permittivity of the material used, the lower the parasitic capacitance.

About Hitachi, Ltd.

Hitachi, Ltd., (NYSE: HIT / TSE: 6501), headquartered in Tokyo, Japan, is a leading global electronics company with approximately 356,000 employees worldwide. Fiscal 2005 (ended March 31, 2006) consolidated sales totaled 9,464 billion yen ($80.9 billion). The company offers a wide range of systems, products and services in market sectors including information systems, electronic devices, power and industrial systems, consumer products, materials and financial services. For more information on Hitachi, please visit the company's website at http://www.hitachi.com.

About Hitachi Chemical Co., Ltd.

Hitachi Chemical Co., Ltd. (TSE: 4217) headquartered in Tokyo, Japan, is an innovating global chemical company, with approximately 17,000 employees consolidated, fiscal 2005 (ended March 31, 2006) consolidated sales totaled 602.7 billion yen ($5.2 billion). The Company offers diverse range of products, including Electronics Related Products, Advanced Performance Products, and Housing Equipment and Environmental Facilities. For more information, please visit the Company's web site at http://www.hitachi-chem.co.jp/english/.

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