PRESS RELEASE

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STMicroelectronics, CEA-Leti and AIXTRON Develop Ultra-Thin Gate-Insulation Process for Advanced CMOS Transistors

Industry first as ST and CEA-Leti joint development research program demonstrates excellent results for new advanced process technology

Geneva, May 26, 2004 – STMicroelectronics (NYSE: STM) today announced that ST, CEA-Leti and AIXTRON have developed an advanced process technology for the creation of ultra-thin transistor-gate-insulation layers for low-power applications at the 65nm and 45nm CMOS transistor technology nodes. The new process significantly reduces transistor leakage current by the deposition of 'high-k' gate-insulation material.

To meet the future requirements of highly integrated devices postulated by Moore's law and described via the International Technology Roadmap for Semiconductors (ITRS), it will eventually be necessary to introduce new materials into the manufacture of advanced silicon devices. The three companies are developing new process technology aimed at the 45nm or 65nm technology nodes for low-power CMOS platforms optimized for portable applications.

Based on AIXTRON's Tricent® reactor technology, CEA-Leti and ST have created a joint development program for 'high-k' materials, fulfilling the specifications of advanced nano-metric CMOS gate-stacks that require a thick physical layer with a low leakage current equivalent to ultra-thin oxide.

The process, called AVD® (Atomic Vapor Deposition), has demonstrated excellent Equivalent Oxide Thickness (EOT) values of 1.15nm or 11.5Å (Angstroms) based on hafnium dioxide / silicon dioxide / silicon ($HfO_2/SiO_2/Si$) stacks offering leakage current densities as low as $J_L=6.8\cdot10^{-2}A/cm^2$ at 1.5V.

The results were obtained by the Advanced Modules team of researchers from ST and CEA-Leti at ST's Crolles facility using a Tricent AIXTRON 200/300 mm bridge cluster tool. The

HfO_2 deposited layer process was developed in conjunction with AIXTRON, and the wafer processing and the characterization were performed at CEA-LETI facilities in Grenoble.

Metallic oxides of the hafnium family are believed to be excellent candidates for the ‘high-k’ dielectric material that will eventually replace silicon dioxide in the basic CMOS transistor structure.

In addition to the ability to precisely deposit thin dielectric ‘high-k’ layers, the AVD technique also allows the deposition of metal gates necessary for the 45nm-and-below CMOS technology nodes.

“These proof-of-concept results are a first for this process technology,” said Daniel Bensahel, Project Leader and Front-End Program Director at STMicroelectronics. “This joint development program between ST and CEA-Leti, in conjunction with AIXTRON, is not only the first in the industry to implement this advanced process in an industrial environment; but more importantly, it is also achieving excellent results.”

"The co-operation with STMicroelectronics and CEA-Leti is an integral part of our strategic CMOS development effort strengthening AIXTRON’s position in emerging semiconductor applications. By working with one of the leading semiconductor device manufacturers and one of the top research organizations in the industry, AIXTRON will remain at the forefront of cutting edge enabling MOCVD process technology development. We have been highly impressed by the professionalism and the technical competencies of the STMicroelectronics and CEA-Leti team, and look forward to combining our expertise to develop solutions for advanced CMOS devices,” said Tim McEntee, Executive Vice President and COO Semiconductor Equipment/ AIXTRON AG.

About AIXTRON
AIXTRON (Aachen, Germany) is, as verified by an independent market research institute, the world leading supplier of equipment for III-V semiconductor epitaxy. Its equipment is used by a diverse range of customers worldwide to manufacture critical, advanced components such as HBTs, PHEMTs, MESFETs, Lasers, LEDs, Detectors and VCSELs used in fiber optic communications systems, wireless and mobile telephony applications, optical storage devices, illumination, signaling and lighting, as well as a range of other leading edge technologies. Originally focusing on compound semiconductor applications over the last years AIXTRON has broadened its product portfolio to enabling MOCVD Technologies for advanced materials for next generations of mainstream semiconductor devices and Organic LED applications. To date, AIXTRON’s total installed base of systems exceeds 800 tools worldwide. AIXTRON AG (FSE: AIX ISIN DE0005066203) is listed in the Prime Standard and Tec DAX of the German Stock Exchange (Deutsche Börse) and is included in the MSCI World Index.

About CEA-Leti
CEA-Leti (Grenoble, France) is a CEA Grenoble laboratory at the leading edge of European microelectronics and microtechnologies research. It employs about 800 people and with its more than 120 patents filed per year and its 30 start-ups created or being created, it ranks among the major partners of the industrial world. CEA is a polyvalent scientific and technological research organization, specialized in the fields of nuclear power, both civil and military, new energy technologies, information and communication systems and biotechnologies. Its ability to combine fundamental research and valorization in an industrial

framework enables it to play a leading role in innovation. Some 16,000 people are employed at CEA in 10 sites in France.

About STMicroelectronics
STMicroelectronics is a global leader in developing and delivering semiconductor solutions across the spectrum of microelectronics applications. An unrivalled combination of silicon and system expertise, manufacturing strength, Intellectual Property (IP) portfolio and strategic partners positions the Company at the forefront of System-on-Chip (SoC) technology and its products play a key role in enabling today's convergence markets. The Company shares are traded on the New York Stock Exchange, on Euronext Paris and on the Milan Stock Exchange. In 2003, the Company net revenues were $7.24 billion and net earnings were $253 million. Further information on ST can be found at www.st.com.

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Technical Information

AVD® *(Atomic Vapor Deposition)*, developed by AIXTRON, has been proven to be a production worthy deposition approach based on its unique pulsed liquid precursor delivery concept followed by non-contact evaporation.

The basic principle of AVD was initially invented at CNRS (Centre National de la Recherche Scientifique) in Grenoble (France) and further developed by AIXTRON and Jipelec. The process is tailored for the interface-controlled growth of complex oxides and metallic electrodes at atomic precision, for high wafer throughput.

By injecting small quantities of (diluted) liquid sources into a heated vaporizer volume, precise precursor supply mandatory for the complex chemical reaction process can be obtained. The amount of injected liquid is precisely controlled, facilitating growth rates in a range from a few Å/min to 30nm/min. To technically enable the growth of multi-component thin films, layered structures and graded layers, the system was designed for parallel multiple liquid precursor source handling; each source being designed to be independently controlled by injection frequency and opening time. As a consequence, this unique concept therefore adds to the advantages of classical MOCVD, those of the precursor-pulsed deposition mode: high throughput (>20 wafers/h @ 5 nm of HfO2), atomic precision of the deposition thickness, multi-component oxide availability, nano-laminate and spicing, nucleation layer control, and, last but not least, large precursor variety (i.e., no self-limitation).

Another critical point is the linearity of the AVD® growth. At precursor injection frequencies of three pulses per second, the observed growth rate was found to be 0.6Å per injected precursor pulse, which proves that thickness controllability for complex oxides can be achieved at atomic level.

As shown in the Figure, excellent EOT (Equivalent Oxide Thickness) values of 11,5 Å have been recently demonstrated on HfO2 /SiO2/ Si stacks at leakage current densities as low as $J_L = 6.8 \cdot 10^{-2}$ A/cm^2 @ 1.5 V.

As a consequence, AVD® is gaining increasing momentum in the semiconductor industry for the deposition of 'high-k' oxides. Moreover, metals can be deposited using the same technique with output scheduled for both metal gate of the CMOS transistor or electrode for MIM generic structures for the capacitor.

Part of the results has been obtained within the framework of the MEDEA+ T207 project. In order to strengthen the actions, several key partners are participating: CNRS/LMGP (Laboratoire des Matériaux et du Génie Physique) for the basic understanding of the physical phenomena and the test of new materials elaborated by AVD®, Air Liquide (France) for the qualification of the new precursors, Epichem (ex-Inorgtech, United Kingdom) for the supply of the necessary precursors, Jipelec (now Qualiflow) for the improvement and qualification

of precursor injection concepts, and Jobin&Yvon (Horiba group, France) for in-situ optical characterization of the deposition.

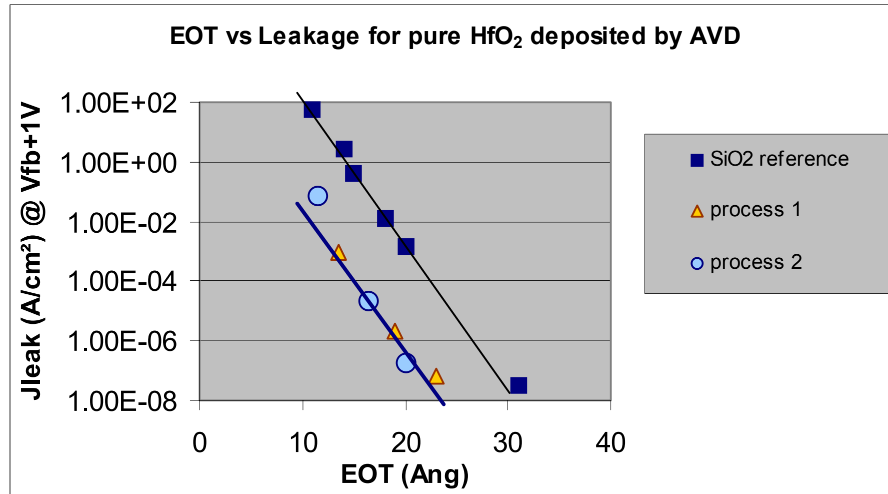

Figure 1: EOT vs. leakage plot of TiN/HfO2/SiO2/Si gate stacks.

Background information on other companies involved in the development:

CNRS/LMGP (Laboratoire des Matériaux et du Génie Physique, Grenoble, France) is a technological university composed by the association of eight high-level engineer schools, strongly connected to CNRS via 26 associated laboratories. A large part of its research activity is related to material science and electronics. The laboratory involved in this project have more than twenty years of experience in the CVD deposition of thin layers of complex materials (thermodynamically calculations, chemical compatibility between the substrate and the layer, MOCVD and CVD deposition of carbides, nitrides, silicide and oxides). Since 1994, a new source principle for the CVD deposition of complex materials has been developed in LMGP and applied to the deposition of oxides like Ta_2O_5, ZrO_2, AL_2O_3, Y_2O_3, $SrTiO_3$, $BaTiO_3$ This system, which allows a "digital growth" at nanoscale size of amorphous, crystallized or epitaxial layers, has been patented by CNRS. A technological transfer, associated to a license for the industrial development of this source has been done in 1999 to JIPELEC and Aixtron.

Inorgtech/Epichem (UK), founded in 1986, manufactures oxide and nitride precursors for a range of materials applications, including the microelectronic circuit industry with the annual capability of a few hundred grams to a few hundred kilograms per item. Inorgtech synthesizes about a hundred different molecules a year most of which are sold internationally to research and development customers. In the semiconductor field Inorgtech makes precursors for diffusion barriers, high K dielectrics and ferroelectrics. Since January 2000 Inorgtech has been owned by Epichem Ltd.

AIR LIQUIDE (Jouy-en-Josas, France) is the worldwide leader of gas companies and one of the major suppliers of gases, chemicals and related equipment for IC manufacturers. In its R&D center, located in Jouy-en-Josas (F), new processes for production and/or purification of gases & chemicals and related analysis methods are developed. This R&D department works in relationship with the R&D centers in Chicago and Tsukuba. In the project, AIR LIQUIDE will be involved in Task 2.1. Main contribution will be in analysis and monitor thermal processes involving potentially suitable precursors capable of producing High K dielectrics films working in Close cooperation with the other task Partners.

HORIBA/Jobin-Yvon, is specialised in design and manufacturing of optical based system for metrology (film thickness measurement) and process control. Jobin Yvon is a world leading company in the design and manufacture of high precision optical instruments for characterisation of thin films with a 20%-80% split between domestic and export sales.

JIPELEC was founded in 1995 by a team of engineers with more than 15 years experience in design and construction of RTP and RTCVD systems. The company was acquired by Qualiflow (F) in 2002.