## Introduction to the Dielectric Science and Technology Division

**by Robert L. Opila**
**Division Chair**

The front cover of *Interface* illustrates one of the greatest challenges and successes of dielectrics in microelectronics today, the growth of a layer of $SiO_2$, 60 nanometers long and 1.2 nanometers thick, that is essentially defect free. This electronic gate, approximately 240 atoms long by 5 atoms thick, permits precise control of the flow of electrons across the channel of the transistor. The work shown here was done by Greg Timp and his colleagues at Bell Labs, Lucent Technologies. In this case, it is the insulator that ultimately controls the performance of the transistor. The work represented on the cover is just one example of how the interests of the Dielectric Science and Technology Division of ECS are having some of the greatest impact in the field of microelectronics.

The Semiconductor Industry Association (SIA) has picked out two distinct areas in which the performance of insulating materials must improve in the coming years. The first area is high dielectric constant materials. Here, instead of growing a gate dielectric of $SiO_2$ that has a dielectric constant, relative to vacuum, of approximately 4.0 and is 1.2 nanometers thick; a gate material of $Ta_2O_5$, with a dielectric constant of 25, might be deposited 7.5 nanometers thick. This increased thickness would certainly give more room for production variability. However, any electrical defects in the bulk of the $Ta_2O_5$, or at either of the interfaces, might degrade the properties of the transistor. For this reason, the possibilities of stacked gates consisting of $SiO_2$ below the $Ta_2O_5$ are being considered. Tantalum pentoxide is not the only material being considered. For shorter term usage, many engineers are looking to use silicon nitride or variously composed silicon oxynitrides as gate dielectrics. On the other extreme, materials like barium strontium titanate have dielectric constants as high as 100.

The second area in microelectronics is low dielectric constant materials. As the gates become smaller and faster, one of the leading limitations is the capacitance and resistance of the interconnecting metal lines and insulators. The metal lines are typically isolated from

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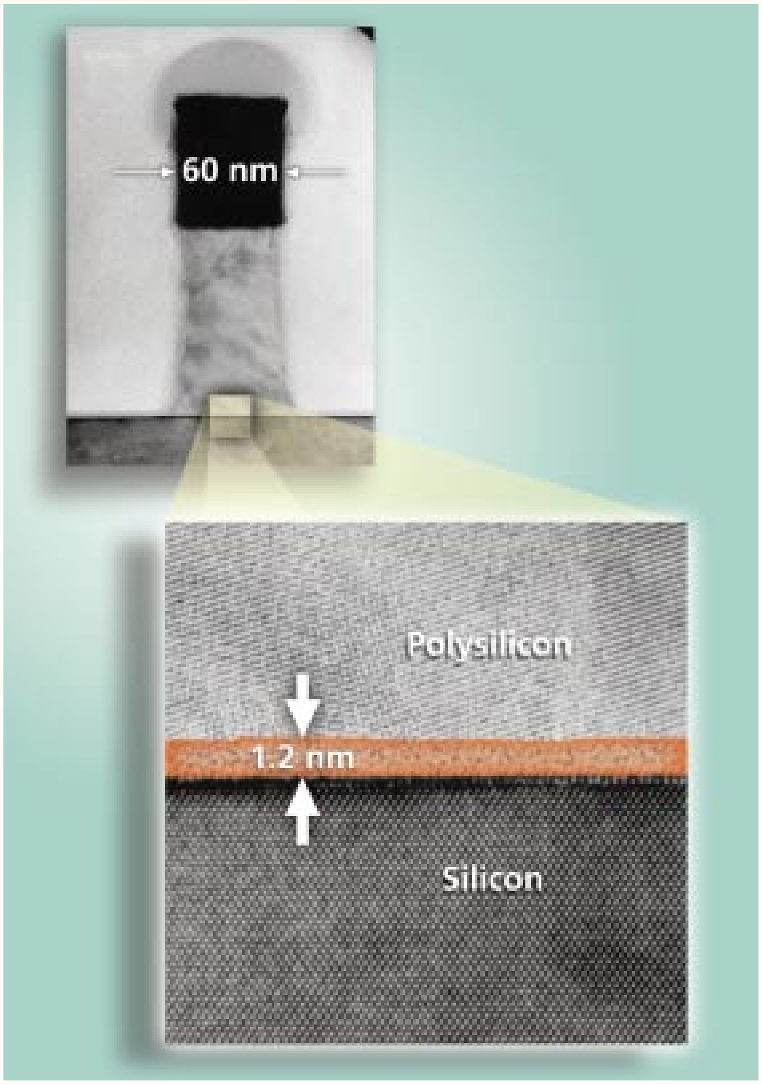
***Our Featured Division***

# Dielectric Science and Technology




*Transmission electron micrograph of an MOS transistor with a channel lengh of 60 nanometers and an oxide thickness of 1.2 nanometers. The micrograph was taken by Frieder Baumann and the transistor was fabricated by Greg Timp and colleagues, all of Bell Labs, Lucent Technologies.*

## *Our Featured Division*

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one another by insulators that are much thicker than the gate dielectrics. For lower resistance, some members of the microelectronics industry are changing their metallization from aluminum to copper. To lower the capacitance of these structures, the dielectric constant of the intervening insulators must decrease from the 4.0 of $SiO_2$ to the low 3's of fluorinated silica glasses, to the 2's of various polymers that are low in hydrogen or rich in fluorine, to the 1's of various structures that include a large amount of void space and retain their mechanical and electrical integrity. Thus, low and high dielectric constant materials are the subject of one of articles in this issue of *Interface*.

Because dielectrics have such a large impact on microelectronics, the DS&T Division holds many symposia jointly with the Electronics Division. We also try to work with other societies including the IEEE. Because of the importance of polymers in electronics, one of our biggest successes has been a joint symposium, Symposium on Polymers for Microelectronics (formerly the DuPont Symposium), held every 18 months at the Winterthur Museum and Gardens in Delaware on the uses of polymers in microelectronics and their packaging (http://www.symposiumonpolymers.com). Because of the growth in the use of polymers in microelectronics, the scope of this conference has also evolved.

Materials are insulating because of the energy gap between the electron levels that contain the valence electrons and empty levels that would contain the conduction electrons. This band gap can be used to detect light. When a photon of sufficient energy is absorbed by the insulator, an electron moves from the valence band to the conduction band, and can be detected as a photocurrent. Almost every ECS meeting includes a symposium that explores the use of dielectric materials. As telecommunications and rapid computation become more dependent on processing of light, we expect research in this area to grow.

The DS&T Division of ECS has long recognized that it is insufficient to merely produce and understand materials with the correct dielectric constant, but it is important to fully integrate the material into the device and manufacturing process in which it is used. To this end, our Division has paid close attention to the effects that microelectronics processing have had on the environment, and what we can do to improve it. The DS&T Division yearly sponsors a symposium dedicated to the role that microelectronics manufacturing plays in the environment from many different view points. Other traditionally strong areas for the division include plasma processing, chemical vapor deposition, metal/polymer interfaces, and electronics reliability. The current list of all of our upcoming symposia can be seen on the Web at: http://electrochem.org/divisions/dstsymp.html.

We recognize outstanding contributors to the field of Dielectric Science and Technology through the Callinan Award, given each spring. The award is named after Thomas D. Callinan, who served as Chairman of the Division twice and as a Division Editor of the *Journal* until his untimely death in 1963. Previous winners include Werner Kern, inventor of the RCA cleans for silicon substrates; Bruce Deal, who along with Grove first described the mechanism for the oxidation of Si; and Dennis Hess, a pioneer in the field of Si oxidation and plasma treatments.

The Dielectric Science and Technology Division of ECS continues to grow and serve as one of the most active divisions of the Society. Our current leadership includes Robert Opila as chair, Richard Ulrich as vice-chair, Henry Hughes as treasurer, Cindy Reidsema Simpson as secretary, Jamal Deen as symposium chairman, Katalin Voros in charge of awards, and Durga Misra as membership chairman. We would be glad to hear from anyone who is interested in the activities of the Division. ■

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### Dielectric Science and Technology Division Future Symposia Plans

#### Hawaii — October 1999

*Corrosion and Reliability of Electronic Materials and Devices* (co-sponsored by the Corrosion Division); *Plasma Etching Processes for Sub-Quarter Micron Devices* (co-sponsored by the Electronics Division); *Interconnects and Contact Metallization for ULSI* (co-sponsored by the Electrodeposition and Electronics Divisions); *III-V Nitride Materials and Devices* (co-sponsored by the Electronics and High Temperature Materials Divisions); *Sixth International Symposium on Diamond Materials* (co-sponsored by the High Temperature Materials Division and the Japan New Diamond Forum); *Fifth Symposium on Low Temperature Electronics* (co-sponsored by the Electronics Division); *Third International Symposium on Chemical Mechanical Polishing in IC Device Manufacturing* (co-sponsored by the Electronics Division); *Electronics/Dielectric Science and Technology Joint General Session*; *Advanced Luminescent Materials and Quantum Confinement* (co-sponsored by the Luminescence and Display Materials and the Electronics Divisions).

#### Toronto — May 2000

*Fifth International Symposium on Low and High Dielectric Constant Materials: Materials Science, Processing, and Reliability Issues*; *Plasma Processing XIII* (co-sponsored by the Electronics Division); *Third International Symposium on Environmental Issues with Materials and Processes for the Electronics and Semiconductor Industries* (co-sponsored by the Electronics Division); *Electrochemical Processing in ULSI Fabrication III* (co-sponsored by the Electrodeposition and Electronics Divisions); *Fourth International Symposium on the Physics and Chemistry of $SiO_2$ and the Si-$SiO_2$ Interface* (co-sponsored by the Electronics Division); *Dielectric Science and Technology/Electronics Joint General Session*; *Rapid Thermal and Other Short Time Processing Technologies II* (co-sponsored by the Electronics and High Temperature Materials Divisions); *Fifteenth International Conference on Chemical Vapor Deposition: CVD XV* (co-sponsored by the Electronics and High Temperature Materials Divisions).