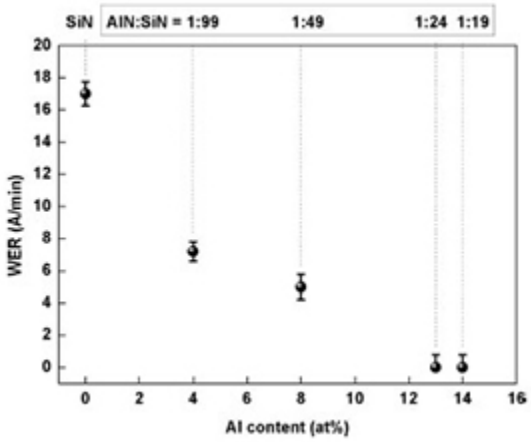
Docket #: S15-195

CMOS-compatible fabrication of uniform, nm-scale insulating thin films for integrated circuits

Researchers in Stanford's Nanoscale Prototyping Laboratory have developed a low-temperature process for fabricating etch-resistant, pinhole-free spacer dielectrics a few nanometers thick. This technology uses plasma enhanced atomic layer deposition (PEALD) to create a silicon nitride (SiN)-aluminum nitride (AlN) composite layer that has insulating properties comparable to pure SiN. Previously, similar levels of etch rate and leakage current could only be achieved in films deposited at temperatures close to 800^{o}C. This new PEALD process can be performed at 350^{o}C, enabling continued scaling of next generation transistors and memory in advanced integrated circuit manufacturing nodes.



Measured wet etch rates for composite films of AlN and SiN as a function of Al content measured by XPS. The x-axis on the top of the graph indicates the AlN:SiN cycle ratio corresponding to the XPS-measured Al content displayed at the bottom. The error bars represent the standard deviation from nine measurements on the same sample.

Stage of Research
The inventors have used this process to fabricate films at 350^{o}C and demonstrated controlled AlN doping of the composite film. They produced films with wet etch rates in hydrofluoric acid too small to measure and electrical insulating properties essentially the same as pure SiN (50nA/cm2 @ 2MV/cm). Additionally, the AlN-SiN composite film is still easily etched by reactive ion etching in Cl_2 or BCl_3 chemistries similar to processing for SiN etching.

Applications

- **Nanofabrication of next generation transistors and memory** - process for creating etch-resistant insulating thin film spacer dielectrics with end user applications such as:
  - nanomechanical systems
  - memory/DRAM
  - bio-implantable electrical transducers/sensors

Advantages

- **CMOS-compatible process** - plasma enhanced atomic layer deposition is performed at 350^{o}C
- **Nanometer-scale film** - produces conformal, pinhole free film at thickness of a few nm or more
- **High performance** - low leakage current with insulating properties the same as pure SiN (50nA/cm^2 @ 2MV/cm)
- **Etch resistant** - wet etch rate in hydrofluoric acid too small to measure, more than an order of magnitude better than other thin films deposited at a similar temperature

Publications

- Kim, Y., Provine, J., Walch, S. P., Park, J., Phuthong, W., Dadlani, A. L., ... & Prinz, F. B. (2016). Plasma Enhanced Atomic Layer Deposition of SiN-AlN Composites for Ultra Low Wet Etch Rates in Hydrofluoric Acid. *ACS applied materials & interfaces.*

Patents

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