



Semiconductors

Forge Nano's high-productivity, turn-key processes are especially suitable for challenging semiconductor applications requiring highest quality, extremely conformal ALD films over area-enhanced structures. In particular, high-K dielectrics, metal-insulator-metal (MIM) film stacks, ultra-conformal SiO₂ for trench isolation and ALD-Cap for chip passivation.

High-K Dielectrics

Advanced capacitor structures with area enhancement approaching 50X stretch the limitations of ALD precursor delivery, especially since precursors suitable for High-K dielectrics such as hafnium and zirconium are extremely low-volatility. Forge Nano combines the high precursor utilization efficiency of *SMFD-ALD* with innovative chemical sources and integrated millisecond-response ALD manifold to deliver turn-key, high-productivity capacitor and transistor manufacturing solutions at sub-second cycle times.

Forge Nano's sub-second cycle time HfO₂ and ZrO₂ dielectrics, in combination with top and bottom TiN electrodes, are tailored for advanced capacitor applications at the FEOL while TiN/Ta₂O₅/TiN stacks are implemented for the manufacturing of advanced RF and BEOL memory capacitors.

The pursuit of low EOT, low leakage current and high electron mobility transistors depends crucially on the interface between silicon and the transistor gate dielectric. With its newly introduced proprietary process that enables deposition, for the first time, of high-quality true ALD SiO₂, Forge Nano's engineered hafnium silicate provides a key, highest quality interface to HfO₂. In addition, our turn-key, high-quality Al₂O₃ is the most cost-effective solution for emerging Al₂O₃ based floating gate devices, such as flash non-volatile memory and ASIC.

Trench Isolation

Forge Nano has recently introduced a proprietary process that enables, for the first time, sub-second cycle time deposition of high-quality, true ALD SiO₂ at a wide temperature range. Trench isolation with conformal SiO₂ ALD over deep and re-entrant trenches is now available on our [APOLLO](#) wafer processing systems.

ALD-Cap Passivation

ALD-Cap[®] substitutes SiN-Cap for a proven, MIL-SPEC enhanced reliability in harsh environments. Forge Nano's **ALD-Cap**[®] is a lower-cost substitute with improved manufacturing yield. **ALD-Cap**[®] is particularly suitable for passivation of compound semiconductors, RF ICs, power ICs, analog and sensor ICs, where the reliability of SiN-Cap passivation is becoming increasingly marginal with generations advancement.

Compound Semiconductors

Compound semiconductor manufacturing employs ALD of high-K dielectrics and TiN conductive films for improved transistor and capacitor performance and manufacturing yields. Stacks of GaAlN/Ta₂O₅/TiN and TiN/Ta₂O₅/TiN, along with complementary, in-situ surface preparation available from Forge Nano are migrating into next-generation compound semiconductor power, LED and RF ICs.

Advantages and Benefits:

- High productivity sub-second cycle time ALD
- Conformal deposition into nanometer size features with aspect ratios in excess of 100 and area enhancement in excess of 50X
- Composite dielectric films for enhanced thermal stability and interface engineering
- Reproducible and scalable processes
- Highest quality dielectric layers with high dielectric constant & dielectric strength
- Monolayer controlled film composition and interface engineering
- Seamless incorporation of nanolaminates
- Sub-nanometer interface roughness
- High throughput <300 °C TiN true ALD process
- MIL-SPEC reliability with 200 nm of ALD-Cap® passivation layer

About Forge Nano

Forge Nano is a leading materials science company harnessing the power of Atomic Armor, the company's proprietary ALD nanocoating technology, to accelerate manufacturing innovation, transform product performance and achieve a more sustainable future for a range of industries around the world. Atomic Armor produces superior coatings that can unlock a material's performance at the atomic level and deliver custom solutions from small-scale R&D and laboratory work to large-scale, high-volume production lines. A range of materials can be enhanced through Atomic Armor, including batteries, medical devices, catalysts, propellants and 3D additives. Forge Nano has received major support and signed meaningful partnerships with Volkswagen, LG Technology Ventures, Mitsui Kinzoku, Air Liquide and Sumitomo Corporation of Americas, largely as a result of the company's innovation in the Lithium-ion battery industry and successful track record of improving product performance and safety while reducing cost.

Forge Nano's Capabilities

- **>20 in-house ALD systems for coating of wafers, powders and objects**
 - Including research, pilot and commercial scale systems capable of processing anywhere from 1.0 g to 30,000 kg powder or extrudates per day
 - Fast deposition times up to 30nm per minute for rapid Al₂O₃ ALD coating solutions
- **The world's most knowledgeable and experienced team for ALD onto a range of materials**
 - PhD scientists, certified Professional Engineers, career scientists
 - 20+ years' experience designing and building powder ALD systems

Working with Forge Nano

Forge Nano assists customers daily with both R&D and commercialization of ALD-enabled materials. For R&D, we offer research services for proofs of concept and also sell our R&D equipment globally. For commercialization, we offer joint development of products, production equipment and IP licensing.