

Flat Panel Displays

Emerging display technologies, such as OLEDs, touch screens and flexible TFTs, require improvements in thin film technology over the current performance of Si-based TFTs. ALD can speedup development and improve yield due to its repeatable, atomic-level control, along with its high film quality, uniformity, and conformality.

The [HELIOS](#) line of industrial systems enables, for the first time, high productivity, production-scale ALD manufacturing on large panels. Forge Nano's SMFD-ALD technology enables low temperature deposition at throughputs comparable to sputtering and CVD, providing a superior performance and cost-competitive alternative.

Transparent Conductive Oxide

Indium tin oxide (ITO) is currently the dominant transparent conductor oxide (TCO) of choice. Increases in indium price, as well as the inherent limitations of ITO deposition drive the need for ITO replacements. ITO has limited resiliency and it tends to wear out and crack when bent. In addition, some of its electrical or optical properties, such as low carrier mobility and rough interface may be inadequate for some applications.

Forge Nano's ZnO:Al provides a robust and stable ALD process for TCO applications, including organic light emitting diodes (OLEDs), touch screens, flexible displays and solar. Our SMFD-ALD systems give you the unmatched capability to deposit thick ZnO:Al ALD layers at low temperatures with high volume productivity. The [HELIOS](#) line is designed to deposit on large panel sizes, while the [APOLLO](#) line is geared toward wafer deposition and handling.

Advantages and Benefits:

- Fast deposition at LOW temperatures
- Stable precursors
- High yield, repeatable process with high alloying accuracy
- Minimal setup and optimization time
- Seamless alloying without throughput penalty
- Highest quality films
- Superior uniformity
- 100% conformal coverage

OLED Encapsulation

Organic light emitting diode (OLED) devices are extremely sensitive to moisture and oxygen and therefore must be protected with a high-performance encapsulating layer. OLEDs require very low permeability levels- for example, water vapor transmission rates (WVTR) $<10^{-5}$ g/m²•day.

Such low levels of permeability require extremely low pin-hole density. Atomic layer deposition is the only technique that can achieve this level with a film as thin as several hundred of angstroms. Forge Nano's ALD-Cap[®] has been tested to $< 10^{-6}$ gm³/m²/day WVTR on PET and PEN sheets and was applied to thousands of square meters of flexible polymer sheets for solar/OLED protection applications

Advantages and Benefits

- 100% conformal
- Ceramic films
- Extremely low-permeability barrier to gases, moisture, and more ($< 10^{-6}$ gm³/m²/day WVTR)
- Flexible, applied to 1,000s of m² of flexible PET/PEN sheets
- Superior uniformity
- Thin coating (200-500 nm)
- Low temperature deposition (down to 70° C)
- Atomic level control of film properties

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.