Welcome to **Advanced Directional Sputtering (ADS)**

Evatec's Senior Program Manager, **Kai Wenz**, introduces the latest PVD technology capability in Evatec's portfolio and gives us a flavor of some of the markets where the enhanced capability can help deliver new levels of device performance.

Conventional PVD – an industry workhorse

Standard physical vapor deposition (PVD) sputtering is a workhorse technique across all Evatec market segments. In the conventional way, atoms are ejected from a target by energetic ion bombardment and travel towards the substrate in a largely random, isotropic distribution. For planar films or shallow topographies, this solution works well - deposition is fast, uniform, and cost-effective. However, as device architectures have evolved toward smaller geometries, higher aspect ratios, and increasingly 3D layouts, the limitations of standard sputtering have become apparent. In deep features such as through vias, or trenches, Isotropic particle flux tends to:

- Deposit excessively on feature sidewalls, narrowing or closing the opening before the bottom sidewalls are coated.
- Increase the probability of voids.
- Result in incomplete or discontinuous bottom coverage, leading to electrical open circuits or high resistance.

Solving the 3D and high aspect ratio challenge

Directional sputtering addresses these challenges by engineering the angular distribution of sputtered atoms so that they arrive predominantly at almost vertical incidence on the substrate surface. This is achieved using methods such as:

- **Collimated sputtering:** Placing a physical collimator between the target and the substrate to filter out off-angle atoms.
- **Ionized PVD (I-PVD):** Ionizing a significant fraction of the sputtered flux and using an electric field to direct it straight into the features.
- **Long-throw sputtering:** Increasing target-to-substrate distance to naturally narrow the angular spread of incoming atoms.

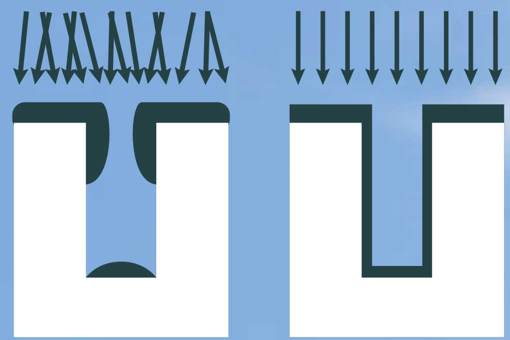


Figure 1: Conventional vs directional sputtering.

The Evatec solutions – SDS and ADS

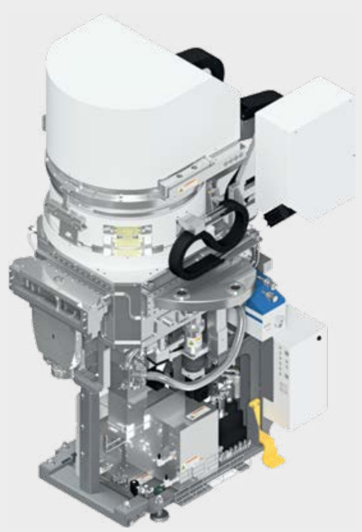
Evatec's ADS stands for Advanced Directional Sputtering and is available for the CLUSTERLINE® 200 and 300 platforms.

ADS is a key development focus for our new frontend capabilities, allowing high productivity with shutter, RF Bias, hot and cold electrostatic chucks at very low particle and metallic contamination levels. For less challenging structures, aspect ratios and technology nodes the simplified SDS (Standard Directional Sputtering) setup with fewer tuning features is available for cost effectiveness.

Key materials are Ti/TiN, Ta/TaN, and Cu, but it can be used and optimized for other materials too.

In today's advanced manufacturing landscape, where structures can be smaller, pitches tighter, and sometimes deeper, with higher performance demands, directional sputtering has moved from a specialty process to a critical enabler. Without it, many state-of-the-art metallization steps in high-performance computing, 5G, and AI (artificial intelligence) hardware would not be manufacturable at volume with the required reliability.

ADS 200 solution for 200mm processing



ADS 300 solution 300mm processing

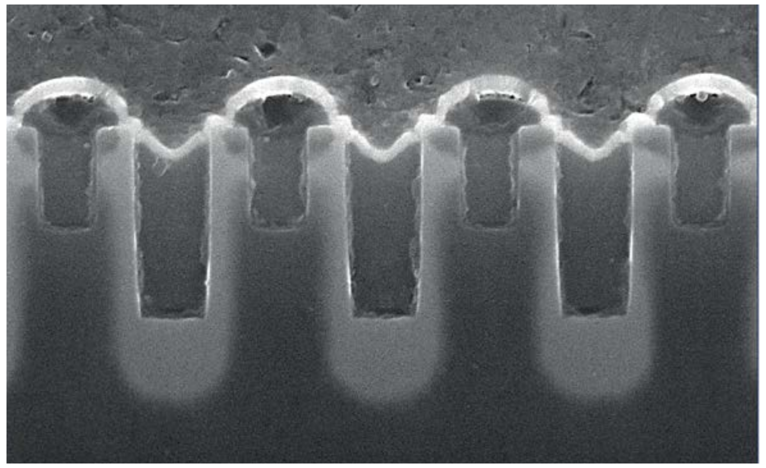
Figure 2

ADS in action

Here are just four application examples where directional sputtering is essential in supporting our customers and their needs:

1. Power Discrete

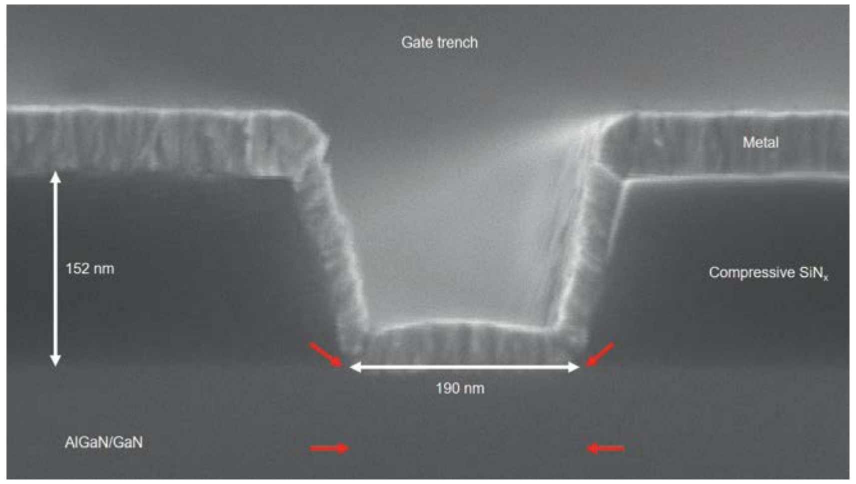
In trench MOSFETs and IGBTs, Ti/TiN layers must form a continuous adhesion and diffusion barrier deep inside high-aspect-ratio trenches. Standard sputtering often causes sidewall overhang and poor bottom coverage, leading to high resistance and reliability issues. Evatec's ADS solution overcomes this challenge.



Sic Mosfet Gate Design - Die Cross Section, SEM View from Rohm Semiconductor – Source: SiC Transistor Comparison 2023 report, Yole Group

2. Wireless

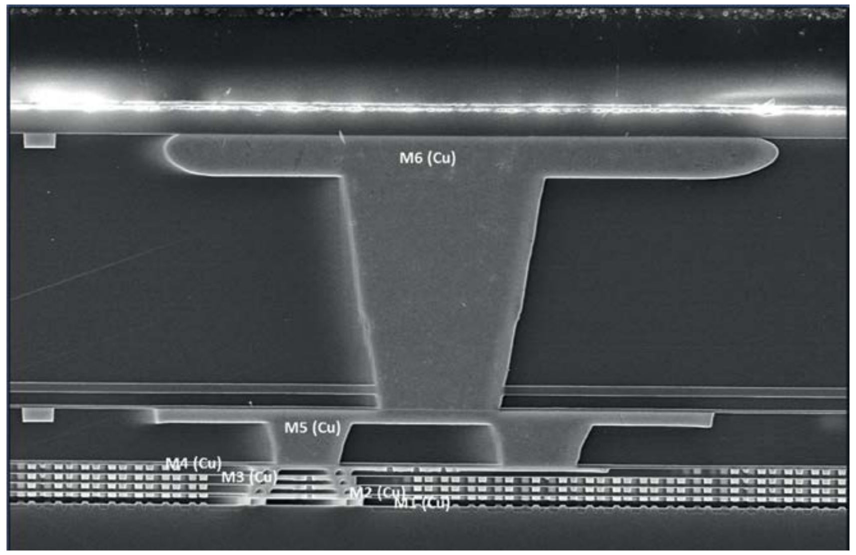
GaAs-based HBTs and HEMTs are the most commonly used technologies for RF power amplifiers. These devices require conformal coatings of metals like WTi, Cu, Au, and Ti, especially Ti/Cu and Ti/Au bi-layers, where Ti serves as a seed layer and Cu or Au as the conductor. ADS technology provides superior conformality and step coverage compared to traditional sputtering, enabling damage-free deposition on complex structures. Its precise plasma control and low ion energy ensure excellent film uniformity and adhesion, enhancing device performance and reliability in demanding RF environments.



BCD 90MN Cross-Section: Thick metal layer in cross-section - SEM view Exploration of high-temperature PECVD SiNx for strain engineering of GaN-HEMTs | Ferdinand-Braun-Institut. Image courtesy of © FBH

3. Frontend

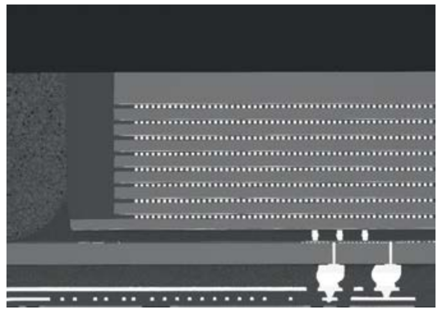
In advanced interconnect fabrication, liner, barrier layers, and seed layers must be continuous and uniformly coated on the sidewall. Depending on the architecture, coating at the bottom may also be required for connection to other features underneath. Typical materials used are Ti/TiN-Al (200 mm) reflow or TaN/Ta-Cu (300 mm) enable void-free Cu electroplating. Typical structures used are contact holes, trenches and dual damascene features. With the trend to smaller structures new materials are under evaluation and the number of interconnects continues to increase.



BCD 90nm Cross-Section: Thick Metal Layer In Cross-Section - Sem View Source: BCD Comparison 2024 Report, Yole Group

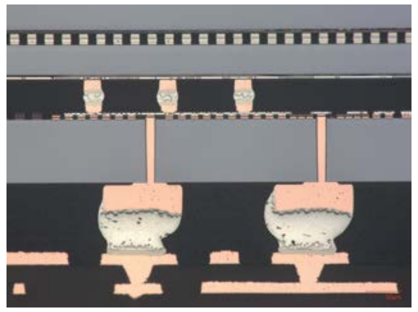
4. Advanced Packaging

For Through-Silicon Via (TSV) seed layers in advanced interposers, continuous metal coverage of typical Ti-Cu to the bottom is mandatory for reliable Cu electroplating. It becomes challenging for standard sputtering to establish a conductive path for higher aspect ratios and via depths, whereas directional sputtering ensures full continuity. In more highly integrated devices, advanced packaging is becoming even more important.



SK Hynix HBM3 – HBM DRAM die: package cross section, SEM view

© Yole Group 2025



SK Hynix HBM3 – Bumps: package cross section, SEM view

© Yole Group 2025

Want to know more?

Got a challenging application? Want to investigate sampling opportunities in Evatec's Competence Laboratory (ECL)? Contact your local Evatec sales and service organization to find out more.