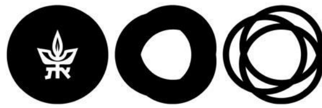

April 10, 2024

The new equipment coming soon to TAU CCNS

1. 200mm CORIAL 210 ICP-CVD Tool.

- The CORIAL 210 ICP-CVD Tool from PlasmaTherm House is a High-Density Plasma Chemical Vapor Deposition System, designed for depositing thin films of device-grade quality thin films, particularly Hydrogenated Amorphous Silicon (a-Si: H) and various Silicon Compounds including Oxides, Nitrides, Carbides, their mixtures and Dimond Like Carbon (DLC).
- The independent control of High-Density Plasma (HDP) source (high ion density) and wafer bias (ion energy) integrated into Inductive Coupled Plasma (ICP) configuration, enables high-rate deposition at low temperatures, even below 200°C. For some applications, adequate film properties are achieved at temperatures as low as 50°C to 75°C.
- The tool is equipped with a vacuum load lock, which significantly reduces the heating-cooling cycle effect on machine throughput.
- The CORIAL 210 ICP-CVD Tool reveals new capabilities.
  - The system can "fill" or conformally coat trenches and vias, even with higher aspect ratios compared to Plasma Enhanced Chemical Vapor Deposition (PECVD) equipment. This capability is crucial for various microfabrication processes.
  - The low-temperature operation enables the execution of "lift-off" processes, using ICP-CVD instead of Physical Vapor Deposition (PVD).
- This new tool complements the existing PECVD system in the Nanocenter, which is slated for an upgrade with new electronic hardware and software before moving to the new fabrication facilities. The gas delivery system in the new facilities provides a comprehensive range of gases, offering full flexibility in fabrication processes. This ensures that users have access to the necessary resources for their specific applications. With both the CORIAL 210 ICP-CVD Tool and the upgraded PECVD system, users at TAU Nanocenter gain access to a wide range of plasma-enhanced CVD equipment. This setup covers an almost unlimited range of cutting-edge applications in thin film deposition and microfabrication.

2. 200mm CORIAL 210IL-187 ICP-RIE Tool.

- The tool is the High-Density Plasma (HDP) Reactive Ion Etcher (RIE) from PlasmaTherm House, configured to work with Corrosive Plasma Chemistries. The HDP is achieved by the Inductive Plasma Coupling (ICP) to the driving RF Power Supply.
- The CORIAL 210 ICP-RIE- is intended for efficient chemical dry etching of metals such as (Aluminum, Gold, Silver, Copper, Titanium, Tungsten, Nickel, Stainless, Iron, etc.), metal oxides such as Saphire (crystalline-aluminum oxide) or Alumina (amorphous aluminum oxide), YAG (a mixture of yttrium and aluminum oxides), etc., as well as semiconductor compounds such as AIIIBV Nitrides, Arsenides, Antimonides, etc. The tool provides stable fast etch rates, and excellent process uniformity, while keeping a high throughput.
- Until now TAU CCNS had no capabilities for dry chemical etching of materials containing heavy metal atoms as constituents. Thin metal and metal compound films were patterned-etched using the Ion Beam Milling (IBL) approach, which is essentially the physical bombardment/sputtering of the etched materials by argon ions with energy of a few hundred electron-volts. Being based on a pure physical bombardment process, the IBM approach is not selective toward etched materials, it is slow, damaging, and dirty. The ion bombardment leads to large surface roughness, creating damage penetrating deeply underneath the etched surface, destroying the whole fabricated device structure. The critical dimensions of the etched features are very limited by the thickness of the etched film, due to the re-sputtering back of the non-volatile sputtered fragments.
- The gas delivery system supporting the new ICP-RIE tool containing gases such as BCl3, Cl2, HBr, NF3, CH4, H2, SF6, CF4, CHF3, O2, and Ar.

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- In the ICP-RIE reactor, plasma consisting of a proper mixture of gases, including a halogen gas such as chlorine or bromine, is used to create halogen ions and free radicals. The free radicals actively react with metal atoms on the surface of etched materials, forming metal halides, which are then removed from the surface by pure chemical reactions or assisted by ion sputtering. The chemical interactions are fast and inherently isotropic. ICP configuration allows the substrate biasing, adding to an anisotropy of the etch process. This allows for precise etching of the metal surface, enabling the creation of intricate patterns or structures.
- In addition, the CORIAL 210 ICP-RIE t system is configured to perform Deep Substrate Etch (DSE) processes of small size high aspect ratio (depth/size ratio) trenches, using multiple repeating cycles of time-shared anisotropic etch and wall passivation steps.

3. 200mm CORIAL 210IL-189 ICP-RIE Tool.

- The PlasmaTherm CORIAL 210 ICP-RIE Tool is the High-Density Reactive Ion Etcher adapted for work with fluorine-oxygen-based plasmas.
- The tool configuration and functionality of the CORIAL 210IL-189 ICP-RIE are very similar to the CORIAL 210IL-187 ICP-RIE Tool, working with corrosive plasma chemistries.
- It is intended mainly for etching silicon oxides in the form of crystalline quartz or fused silica, oxide glasses such as BPSG, BSG, PSG, etc., Pyrex, Gorilla Glass, and silicon nitride.
- Available gases: SF6, C4F8, CF4, CHF3, O2, Ar, N2

Items 1-3 were purchased with funds granted by the Israeli Ministry of High Education and matched by TAU Nanocenter.

4. EVATEC BAK501 E-GUN EVAPORATOR with ION ASSITED DEPOSITION CAPABILITIES

- The EVATEC BAK501 is an industrial-grade e-gun evaporator, for stable and controllable multilayer deposition of metal and dielectric layers with specified properties and excellent uniformity.
- Specific features:
    1. Large substrate-source distance, optimized for lift-off, and damage-free (by X-Ray and secondary electron) depositions.
    2. Predefined deposition processes for popular metals: aluminum, copper, titanium, chromium, nickel, gold, silver, platinum, and palladium.
    3. Metal oxides, such as alumina, silica, titania, etc., are deposited using reactive deposition of metals in an oxygen atmosphere. The reactive deposition is implemented in two regimes:
        1. thermal, when a quartz lamp heats the substrate, or
        2. ion assisted when the substrate is heated by argon/oxygen ion beam.

       Both regimes are available.
    4. 8 pockets (7cc÷40cc).
    5. Manual load.
    6. Samples: from small dies (1.5 cm ×1.5cm) up to ∅6” wafer × 5
    7. Base pressure with cryopump $<2\times10^{-7}$mBar ($<4\times10^{-8}$mBar after 48h)
    8. Reasonable deposition rates (10kW e-gun power supply)
    9. Full automation through pump down, process, and vent and full data logging functionality
    10. Controlled deposition rates and process termination with EVATEC’s QCM monitoring technology. Speed switch between crystals and simultaneous control of up to 4 quartz heads.
    11. DC-driven gridded ∅4cm diameter Ion Beam Source mounted on the bottom of the chamber. The source generates the divergent ion beam, uniformly covering the up to 6” diameter wafers placed on calotte and used for:
        1. substrate ion etching/cleaning

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2. ion plating (ion-assisted deposition)

- Full support by EVATEC's application specialists – process development.

The EVATEC BAK501 was acquired with funds provided by Prof. Gideon Segev and TAU Nanocenter.

5. VST Multifunction PVD system TFDS 6400

- Currently, TAU CCNS intensively uses two Physical Vapor Deposition (PVD) tools for deposition of dielectric and metal thin films:
  1. The VST e-gun evaporator. This versatile tool has been a fundamental part of TAU Nanocenter's fabrication facilities for over a decade.
  2. Penta Magnetron Sputter: The Penta Sputter is another crucial tool for PVD at the Nanocenter. The upgrade made by VST more than 10 years ago allowed its intensive use up to this day.

  Both tools have played a significant role in enabling the Nanocenter to conduct research and fabrication processes. Their longevity and continued usage indicate their importance in the center's operations.

  During the last period, the Nanocenter has faced a significant challenge with these tools due to obsolescence and lack of spare parts. The natural decision to upgrade and trade in these tools with the help of VST, the designer and manufacturer of the tools, is a proactive step towards modernizing Nanocenter's fabrication facilities. Given the extensive use and importance of the equipment, it's understandable that upgrading them is a priority for TAU Nanocenter to ensure the continuity of their research and fabrication capabilities.
- The upgraded VST Tool keeps all functionalities of the old VST e-gun evaporator and Penta sputter.
- The VST Multifunction PVD system TFDS 6400 is implemented as a cluster tool consisting of two modules, coupled through a shared load-lock with the automatic wafer manipulator (transfer mechanism). Each cluster module has its own pumping system, functionality, and control. The first module operates as an e-gun evaporator tool, while the second one is a magnetron sputter. The synchronization between chambers operation is required only during the sample load-unload procedures. VST TFDS-4600 is designed and built to ensure robustness, long service life, and reproducible layer depositions of thin metallic and dielectric films. VST TFDS-4600 offer includes a comprehensive support package, ensuring customer technical success as well as long system life with maximal system utilization.
- Specific features:
  - Substrate holder: 6" water-cooled substrate holder with z-adjustment and programmable in vacuum/in-process rotation; sample adaptor for 4" wafer, sample adaptors designed for smaller samples.
  - Sputtering subsystem:
    - Sputter up, confocal arrangement.
    - five ∅3" magnetron sources operated by DC and RF power supplies, allowing sputtering of both conductive and non-conductive targets.
    - Cryogenic vacuum pump.
    - Simultaneous co-sputtering from 2 sources is supported.
    - 3 gas lines (N_2, Ar and O_2) with Mass Flow Controllers for reactive sputtering
    - The system is fully automatic, controlled by VST control software running on advanced PC/PLC architecture, all modules with their status and all measurements are displayed and can be controlled from graphic HMI.
  - The E-beam subsystem:
    - Cryogenic vacuum pump.
    - 6 crucibles of 7cc volume.
    - An e-beam source with a solid-state power supply, digital sweep, and thickness control system for precise and repetitive evaporation.

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- The system is fully automatic, controlled by VST control software running on advanced PC/PLC architecture, all modules with their status and all measurements are displayed and can be controlled from graphic HMI.

6. Semi-Automatic Surface Grinder Disco DAG810

- New Disco DAG810 Semi-Automatic Surface Grinder will expand TAU CCNS's existing capabilities for, wafer thinning, fabrication of pre-engineered substrates and fabrication of Through Strata Vertical interconnects (TSVs) to enable 3D Integration (3DI) of multiple stacked wafers/chiplets in a single compact package (System in Package- “SiP”).
- Emerging applications, such as Artificial Intelligence, Machine Learning, 5G/6G Networks, and Autonomous vehicles, along with many others, demand greater integration densities and faster data transfer rates.

  3DI is an umbrella name for a range of manufacturing technologies for the integration of multiple dies into a single package. It forms highly integrated systems by vertical bonding and connecting various materials, processing technologies, and functional components technologies. For electrical interconnections 3DI uses TSVs. Today 3DI has been recognized as an effective approach, for the fabrication of integrated heterogeneous Infotech-Nanotech-Biotech systems, with high-density short interconnects, wide bandwidth, low power consumption, small form factors, and very low cost. Different components optimized for energy/power budgets can be integrated with processors, memories, wireless and optical communications, MEMS devices, Fluidic devices, and various micro/nano-scale chemical, bio, thermal, mechanical, electrical, and optical sensors.

  A few enabling technologies must be developed and introduced into the existing fabrication process-flows to support 3DI and TSVs:

  1. aligned wafer bonding (permanent or temporary), with thin wafer handling mechanisms.
  2. extreme wafer thinning and edge trimming for obtaining damage-free thin wafers.
- During the last few years, there have been more and more requests from CCNS’s customers related to 3DI. Despite growing demands, the lack of grinding and wafer bonding capabilities at CCNS prevents these requests from being executed. It is worth noting that, despite the worldwide interest in 3DI, and its recognition as enabling the future market’s killer applications for the coming decades, the CCNS is the only public fabrication facility in Israel, focusing on 3DI solutions. Moreover, CCNS is the only academic structure in Israel, that took on the mission to become the Israeli know-how supplier for leading and affordable solutions in the field. CCNS’s R&D process engineers are already collaborating with industry leaders, such as SCD, IAI, NVIDIA, QUALCOMM, INTEL, etc. others, developing TSV and other 3DI-relevant fabrication technologies. We believe that an acquisition will position TAU CCNS as the Israeli 3DI center of excellence, providing relevant fabrication and consultancy services countrywide.
- As was mentioned above, the bonding and grinding fabrication processes cannot be considered independently, they complement each other and usually run sequentially one after the other. First, a wafer is bonded to a carrier (permanently or temporarily), and then the bonded wafer is ground from the back side to deliver defect defect-free thin layer. So, to complete fabrication sequences, both tools should be acquired together. However, the equipment is expensive, and TAU Nanocenter does not have funds to finance the project. Intel Corporation, recognizing the advantage of research collaboration with academia, provided funds for the purchasing of the Surface Grinder/Polisher Disco DAG810. TAU Nanocenter matched the funds. To acquire the automatic wafer bonder TAU Nanocenter staff together with TAU PIs has submitted a research proposal to the Israel Ministry of High Education.

- Surface grinding/dry polishing plays a critical role in modern semiconductor fabrication by providing the precision, flatness, surface finish, and dimensional control required for manufacturing high-performance semiconductor devices:
  - Semiconductor wafers and substrates require extremely flat and parallel surfaces for precise manufacturing processes. Surface grinders can achieve high levels of flatness and parallelism

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of wafers and substrates, ensuring their uniform processing and accurate deposition of the material layers.
  - Surface grinders can achieve very fine surface finishes, essential for semiconductor applications, where even minor imperfections can affect device performance. Consistent surface finishes are critical for achieving desired electrical and optical properties in semiconductor devices.
  - Surface grinders are used to thin semiconductor wafers to the desired thickness. This is particularly important for advanced semiconductor processes where thin wafers are required to reduce signal propagation delay and improve device performance.
  - Surface grinders can be used in wafer reclamation processes to remove damaged or defective layers from semiconductor wafers. By grinding away the damaged areas, the remaining wafer material can be reclaimed for further processing, reducing waste and manufacturing costs.

- Specific features of the Surface Grinder Disco DAG810:
  - A simple compact, automatic grinder designed for extreme wafer thinning for obtaining damage-free ultrathin wafers:
  - Fits for processing of a variety of materials and electronic components, including hard or brittle substrates.
  - Workpieces up to 200 mm in diameter.
  - Fixed abrasive in-feed grinding,
  - Provides superior precision and uniform grinding results.
  - Surface roughness <10 nm.
  - Grinder with high-rigidity, low-vibration spindle, and chuck table.
- The acquisition of the new tools will give a significant boost to the development and implementation of 3DI technology into existing fabrication process flows, which will make 3D Integration Technology at TAU a reality.

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