ATOMIC LAYER DEPOSITION AND TARGETED APPLICATION AREAS

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**Available Equipment**

- 100 mm single-wafer tool with 2 liquid delivery systems and 2 bubblers
- Roth & Rau 200 mm multi-chamber tool with two ALD chambers, each with:  
  - 2 Direct Liquid Injection Systems  
  - 2 Liquid Delivery Systems

*In vacuo* XPS and *in situ* Raman spectroscopy available on the system as well as CVD for carbon nanotubes (CNTs) and ion-beam sputter deposition.

**ALD Materials and Application Areas**

1. **Metals**
   - **Copper**  
     - Seed layers for metallization of nanoelectronic interconnect systems and through-silicon vias (TSVs) in 3D integration  
     - Functionalization of CNTs and CNT integration in metallization systems  
     - Non-magnetic layer in GMR stacks

   - **Nickel**  
     - Liner and seed layer in interconnect systems and for TSV metallisation  
     - Ferromagnetic film in magnetic/spintronic film systems  
     - Functionalization and metallization of CNTs

2. **Metal Oxides**
   - **Copper Oxide**  
     - Intermediate stage for ALD of copper  
     - Functionalization of CNTs, e.g. for sensors

   - **Nickel Oxide**  
     - Intermediate stage for ALD of nickel  
     - Functional film in magnetic/spintronic film systems  
     - Functionalization of CNTs, e.g. for sensors

   - **Aluminum Oxide**  
     - Passivation layer, e.g. for MEMS, electronic devices, solar cells  
     - Dielectric with high permittivity, e.g. for storage/memory applications  
     - CNT functionalization

3. **Metal Nitrides**
   - **Titanium Nitride**  
     - Diffusion barriers against copper diffusion in nanoelectronic interconnect systems and TSVs for 3D integration  
     - Hard coatings/abrasion protection for MEMS

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**Figures:**

STEM image of ECD Cu fill on a TaN/Ru stack prepared by PVD with Cu seed deposited by ALD. (left); ALD copper oxide integrated with sputtered nickel films. (center); Functionalization of carbon nanotubes by ALD. (right)
### Working Areas

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<tr>
<th>Interconnects</th>
<th>Spintronics</th>
<th>3D Nanostructures</th>
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<tr>
<td>Seed&lt;br&gt;Barrier&lt;br&gt;SiO₂ or ULK Cap</td>
<td>▪ Antiferromagnet (e.g., NiO)&lt;br&gt;▪ Ferromagnet (e.g., Ni, Co)&lt;br&gt;▪ Non-magnetic conductor (Cu)&lt;br&gt;▪ Ferromagnet (e.g., Ni, Co)&lt;br&gt;Substrate</td>
<td>▪ Functionalization of 3D nanostructures by ALD coating with conformal layers or nanoparticles, e.g.:&lt;br&gt;▪ CNTs&lt;br&gt;▪ Nanowires&lt;br&gt;▪ Porous materials</td>
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- ALD Cu seed layers for ULSI interconnects
- Development of ALD processes for liner deposition (e.g., Co, Ni)

![Typical GMR spin valve layer stack](image)

- ALD utilization for spintronic devices, such as GMR sensor systems

![SEM top view images](image)

- Pristine sample

![SEM images of vertically aligned MWCNTs in via holes](image)

Figure: Roth&Rau 200 mm multi-chamber tool for in vacuo processing. (left); ALD modul with direct liquid injection systems (Vapbox 500, Kemstream). (right)

Photo acknowledgments: Fraunhofer ENAS

All information contained in this datasheet is preliminary and subject to change. Furthermore, the described systems, materials and processes are not commercial products.