

Breakout Session 1: Advanced Deposition Processing and Printing for ALD, Thin, Mid and Thick-film Size-Scale

Focus question #1A: VISION AND GOALS - In the next five years, what goals would we like to achieve in advanced deposition processing and printing? What are some of the specific targets we would like to reach? That is, in the future, we would like advanced deposition processes that.....

- Process speed remains a issue, but one needs to consider \$/area and not rate. One needs consider structure-property and material impact on changes in rate as well as cost of equipment. This as often it is possible to enhance rate with add'l equipment. In general 5 to >10X rate increase. However, initial RD cost must not limit strive to continue development.
- Introduce technologies which enable composite systems fabrication which meet goals for individual components, i.e. structural need, PV efficiency and cost/watt, watt.
- Enabling process hybridization with metrology systems to support in-situ QC/QA
- Develop the materials and supportive equipment to enable print of $\pm 1\mu\text{m}$ lines in R2R environment, ideally in next 5-10 year time-frame.
- ALD and other fine size-scale processing is challenged by the substrate, i.e. defects, materials porosity, etc. Regardless, high quality substrates which meet application needs must be available and meet designed cost goals.
- Consideration of parallel vs series processing of layers, components, devices, etc.
- Process modelling, materials modelling!!!!!!!

Focus question # 2A: CHALLENGES - What are the key challenges/barriers/problems to be solved to development and use of advanced deposition processing and printing?

- Enabled HPC to effectively model process and materials to support process development efforts, fully characterized processes.
- Processes and materials supportive of fully “dry” fabrication and/or low-energy processing.
- Use of “non-traditional” substrates and “brittle” materials, including multi-layer fab’d substrates.
- Enabling Room Temperature and Pressure printing at nano-scale and above,
- Expeditious metrological results.
- Non-contact in-situ means to “see” defects in materials in-process.
- Enhanced non-competitive collaboration of technologies.
- Ordered and homogeneous of unique materials, such as carbon nano-tubes.
- Demonstration of ALD at realistic “line-speeds”.
- Membranes supportive of greater selectivity and rate for chemical separations and water

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Focus Question #3A, 3B, and 3C: R&D NEEDS - Drawing on the technical challenges identified, what critical R&D is needed to overcome the major challenges, address scalability, and advance new technologies in R2R, in the breakout area?

- Structure-Property Relationships throughout and post process.
- Establish what are and impact of defect structures.
- Affordable characterization equipment and characterization in 3D space.
- Processes and materials supportive of STP environment processing, i.e. “green”, non-polar, quick-dry solvents, etc.
- Process informatics and “big-Data”
- Definition of Defects and Impact of each for all applications and/or industrial sector.
- In-Line metrology for small-scale fabrication.
- Insuring trained work-force to support technical R&D efforts and needs.

Specific RD topics of interest; In-Line QC/Control Parameters, Scalability of New Manufacturing Methods, Low-Temperature/Pressure Processes and Materials, Printing Vertically Integrated Multilayer Devices at $<1\mu\text{m}$ Size-Scale, Multi-Device Integration.