Toxicity impacts induced by the manufacturing of flexible harvesting membranes: project scope

Funding Sources: KAUST

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Motivations

- Developing flexible and lightweight electronic energy harvesting membranes (potentiality of new designs, easy integration to building and textiles)
- The flexibility of the membrane allows roll-to-roll processing
  - High-throughput and low cost of manufacturing

General goal of the project

Credit: SolarServer.com

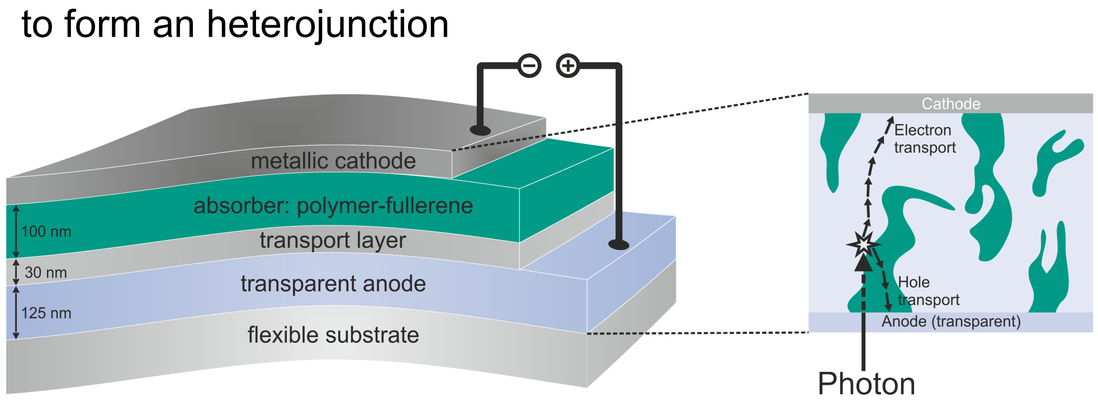
- Delivering a new class of inexpensive, durable, and flexible functional devices that will enable roll-to-roll fabrication of flexible solar cells and smart electronics.
- Aspects to be addressed
  - Processing of materials
  - Predictive computational materials science for long (aging) and short multiphysics timescales
  - Design of durable electronics for in-situ embedding and matrix engineering
  - Green Engineering and total life-cycle analysis
- LMAS focus: Green engineering

Background: thin films

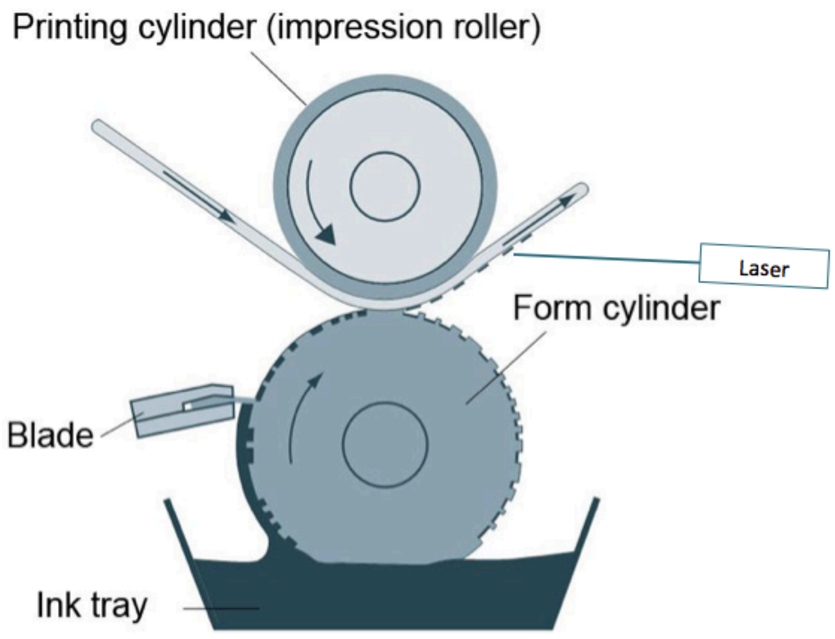
- The high absorption coefficient of the materials enables very thin layers for an optimal light absorption.
- Common flexible thin films
  - Inorganic module: a-SI, CIGS
  - Organic module: semiconductor polymer (bulk heterojunction P3HT:PCBM)
- Lower efficiency than rigid solar cells. However, they require less material and therefore allow flexibility and large scale production using roll-to-roll processing.
  - Photovoltaic energy conversion from sunlight into electricity is expected to be reduced under 0.50 $/W

Structure of thin film

- Thin film are made of a succession of layers:
  - flexible substrate
  - active materials: two layers forming a p-n junction
  - electrodes
- Example of a organic thin film: the active materials are blend to form an heterojunction

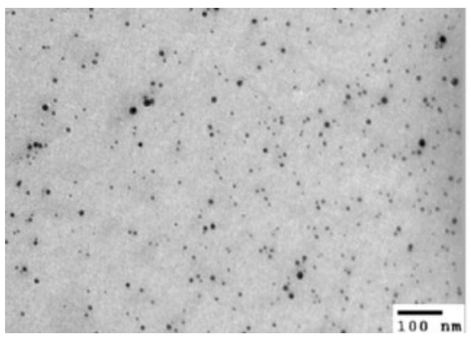


Roll-to-Roll printing for electronics



Coating technique and patterning

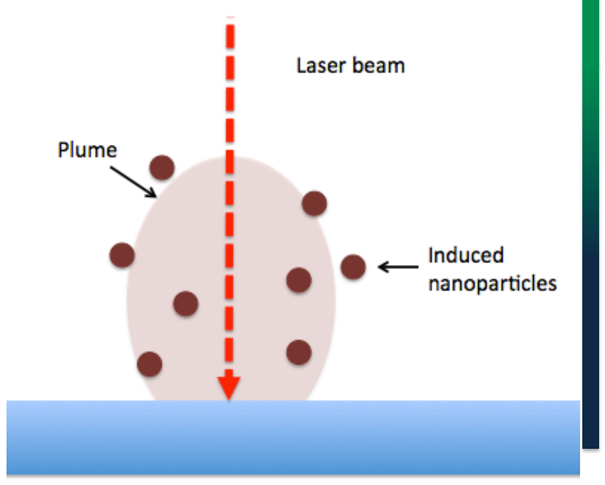
- Ink composed of a matrix and conductive nanoparticles.
- The ink is deposited on the substrate using roll to roll technique and printing cylinders
- Precise patterning of nanoparticle inks using laser ablation process



TEM Image of colloidal silver nanoparticles.
Credit: Chien Dang 2013

Laser Induced Production of Nanoparticules

- The laser ablation of the material induces the production of particles.
- Objectif of no vacuum for large scale processing: particles directly ejected in the air.
- Small particles could get into the respiratory system
  - Toxicity issues



Future Work

- LCA softwares such as Gabi do not take the toxicity effects of the laser induced production of nanoparticles. So far, this process was performed under vacuum conditions.
- Objectives
  - Simulate the production of particles during laser ablation
  - Evaluate the impact of material and laser parameters
  - Integrate this process into GaBi in order to perform an LCA analysis and evaluate the toxicity impact.