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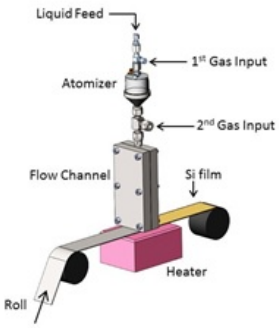
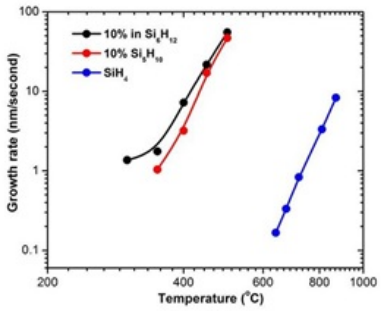
Roll-to-Roll Synthesis of Silicon Thin Films from Liquid Silanes (RFT-447)

Invention Summary

Silicon thin films are fundamental in solar and microelectronic industries, and are presently obtained using expensive low-pressure plasma enhanced chemical vapor deposition (PECVD) using gaseous silanes despite of its low precursor utilization efficiency. Instability and low vapor-pressure of liquid hydrosilanes have limited their use in the semiconductor industries for longtime. Researchers at NDSU have developed a process to synthesis silicon thin films from liquid hydrosilane (Si6H12) at ambient pressure in a roll-to-roll method using atmospheric pressure aerosol assisted chemical vapor deposition (AA-APCVD) that has higher deposition rates compared to the state-of-the-art PECVD. Solubility of solid dopants in the liquid hydrosilane facilitate the deposition of degenerately doped (n & p –type) Si thin films opposed to compressed toxic phosphine and borane gases used in other techniques. Low decomposition temperature (higher activation energy) of cyclohexasilane (Si6H12), a liquid hydrosilane, benefits for a new plasma-free process for the synthesis of silicon nitride films and Si nanowires (with suitable catalyst) at temperatures as low as 350 oC using the AA-APCVD, readily adoptable for large-scale roll-to-roll continuous manufacturing. Liquid hydrosilane compositions consisting of nanomaterials enable hybrid Si films with embedded nanomaterials that have applications in energy harvesting and light emitting devices.



Key Characteristic of AA-APCVD with Si_6H_{12}	
Growth rate	Up to 50 nm/sec
Pressure	Atmospheric
Precursors	Soluble solids/liquids
Temperature	300 – 500+ °C
Photosensitivity	10^3-10^4 (a-Si:H)
Si dep. eff.	~40% (unoptimized)



Benefits

- Roll-to-roll, ambient pressure, low temperature, high deposition rate
- Soluble dopants allow degenerately doped Si thin films without PH3 and B2H
- Plasma free synthesis of a-SiNx thin films
- Vapor-Liquid-Solid based growth of Si nanowires and nanomaterials embedded Si thin films

Applications

These inventions have applicability in the photovoltaics, microelectronics, Li-ion battery (anode),

photovoltaic, display, optoelectronic devices and biomedical market.

Patents

This portfolio contains three separately-disclosed technologies that are all patent pending with worldwide patent rights.

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