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High throughput, room temperature synthesis of cluster assembled silicon based nanostructured materials

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Silicon based nanomaterials, given their appealing tunable optical, electronic and mechanical properties, represent a promising choice in a range of applications spanning from lithium ion batteries, up to photovoltaics and light emitting devices [1]. Standard fabrication methods (e.g. PECVD) suffer however from high processing temperatures (T > 100 °C; not compatible with cheap flexible substrates), low deposition rates (nm/s) and lack of morphology control, being not compliant with industrial requirements [2].
In the present work a novel large area (100 cm2), high yield (up 1µm/min and 300 mg/h), low temperature, plasma-based deposition technique – named Nanoparticles Jet Deposition (NANO JeD) - is presented for fabrication of silicon cluster assembled films. The process is based on the segmentation of the gas phase material synthesis in two steps: (i) precursor dissociation chemistry control in a non-thermal dusty plasma environment, allowing low temperature crystallization and narrow size distribution synthesis of nanoclusters [1]; (ii) physical impaction of nanoparticles via sonic jet at room temperature, ensuring material morphology control [3].
Crystalline volume fraction and grain size, governing the material optoelectronic properties, are tuned by controlling over the processing parameters of the plasma reactor (e.g. gas mixture and coupled RF power), while morphologies ranging from aerogels, to quasi 1D hierarchically organized tree-like structures, up to compact films are obtained by controlling over the aerosol gas dynamics of the jet flow field [3].
The described fine degree of control over material properties offered by presented method makes it suitable candidate for synthesis of nanostructured lithium ion battery anode architectures and dense cluster assembled active materials for thin film transistors.

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Keywords
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