Materials Science & Engineering Doctoral Defense

Development of Nanosphere Lithography Technique with Enhanced Lithographical Accuracy on Periodic Si Nanostructure for thin Si solar cell application

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abstract

In this thesis, a novel silica nanosphere (SNS) lithography technique has been developed to offer a fast, cost-effective, and large area applicable nano-lithography approach. The SNS can be easily deposited with a simple spin-coating process after introducing N,N-dimethyl-formamide (DMF) solvent which can produce highly close packed SNS monolayer on large silicon (Si) surface area since DMF offers greatly improved wetting, capillary and convective forces in addition to slow solvent evaporation rate. Since the period and dimension of surface pattern can be conveniently changed and controlled by introducing a desired size of SNS and additional SNS size reduction with dry etching process, using SNS for lithography provides highly effective nano-lithography approach for periodically arrayed nano-/micro-scale surface patterns in a desired dimension and period. We successfully demonstrate that various Si nanostructures (*i.e.,* nanopillar, nanotip, inverted pyramid, nanohole) can be fabricated with SNS introduced nano-lithography technique by using different etching technique like anisotropic alkaline solution (*i.e.,* KOH) etching, reactive-ion etching (RIE), and metal-assisted chemical etching (MaCE).

In this research, computational optical modeling is also introduced to design the Si nanostructure, specifically nanopillar (NP) in a desired period and dimension. The optical properties of Si NP are calculated with two different optical modeling techniques which are rigorous coupled wave analysis (RCWA) and finite-difference time-domain (FDTD) methods. By using these two different optical modeling techniques, optical property of Si NPs in different periods and dimensions has been investigated to design ideal Si NP which can be potentially used for thin c-Si solar cell application. From the results of our computational and experimental works, we found that a low aspect ratio Si NPs fabricated in periodic hexagonal array can provide highly enhanced light absorption for target spectral range (600 ~ 1100nm) which is attributed to (1) effective confinement of resonant scattering within Si NP and (2) increased high order diffraction of transmitted light providing extended absorption length. From our research, therefore, we successfully demonstrate that our nano-fabrication process with SNS lithography can offer enhanced lithographical accuracy to fabricate intended Si nanostructure which can realize enhanced light absorption of thin Si solar cell.

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