Fabrication of Grating-based Solar Thermal Absorber using Deep Neural Network and Nanoimprint Lithography

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In recent decades, clean and abundant solar energy has been considered as a promising renewable energy source because of the rising fossil fuel prices, global warming and environmental pollution. One of the efficient ways to utilize solar energy is to make use of solar thermal energy system. Compared to conventional photovoltaics, advantage of solar thermal energy conversion is the use of almost all solar spectrum and enables high energy conversion efficiency. To obtain the maximum conversion efficiency of solar radiation, solar absorber should possess an optical absorption of visible and near-infrared (IR) spectral region in the solar spectrum while suppressing mid-IR emission at high temperatures. However, it is remains a challenge to obtain a high efficiency solar absorber by a conventional fabricating methods. In order to overcome the fabrication difficulty, we propose the subwavelength-sized nanostructures.

In designing solar absorber using nanostructure, numerical simulations are often used to estimate electromagnetic behaviors of structures. For example, rigorous coupled-wave analysis and finite-difference time-domain are commonly employed. The simulation methods, however, are based on heavy computation resources and time. In this paper, we will employ a state-of-theart modelling technique, deep learning to reduce the cost of calculation. To avoid computing extreme number of samples, only regulated amounts are prepared and used as data set to train deep neural network. Designing nanostructured metamaterial for a broad-band solar thermal absorber is considered as an example problem. Moreover, several analyses utilizing evolutionary algorithm or Monte Carlo method, which require tremendous number of performance calculations, will be performed on the trained network. Here, we showed that deep learning could most accurately imitate the original performance and also effectively reduce overall designing costs 0.5 to almost zero times than designing with simulation only.

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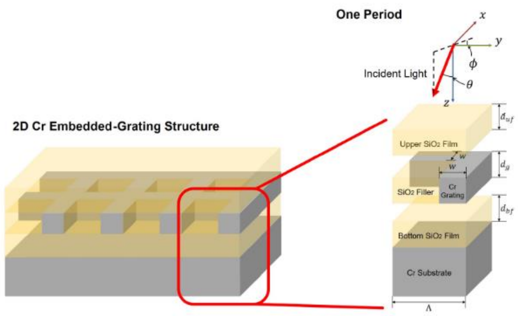

Figure 1. Two dimensional and one periodic schematics of Cr embedded-grating solar absorber structure

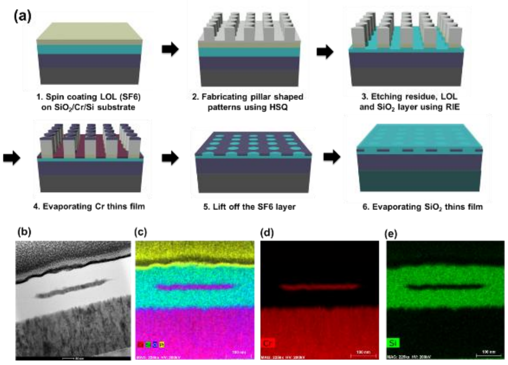

Figure 2. (a) Fabrication processes of Cr embedded-grating solar absorber structure, (b) TEM-SEM image of fabricated Cr embedded-grating solar absorber structure; (c)-(e) HAADF-STEM cross-sectional image and EDX elemental mapping image of Cr embedded grating structures. Two dimensional and one periodic schematics of Cr embedded-grating solar absorber structure.