Supporting theory

Fresnel theory has been employed to reveal the potential mechanism of transimission enhancement in SiO₂ incorporated TiO₂ photoanodes.

$$n = \sqrt{n_0 n_s} \tag{S1}$$

where n_0 is the refractive index in upper layer, n is the refractive index in the middle layer, and n_s is the infractive index in the lower layer.

It is a prerequisite to match the refractive indexes well of mediums well in fabricating an antireflective film for transmission enhancement. The refractive index (n_0) of incident light in air is 1, therefore, *n* should match well with square root of n_s . It is known that the refractive index of SiO₂ (n) is around 1.5, whereas that is 2.52 for TiO₂ (n_s) , suggesting that the square root of n_s is approximately 1.59. However, the further decrease of ns benefiting from the the nanoporous structure of TiO₂ results in a complete matching of $\sqrt{n_0 n_s}$ with *n*.

Actually, the optical dispersion of TiO₂ obeys [S1]:

$$n_s^2 = 5.913 + \frac{0.2441}{\lambda^2 - 0.803} \tag{S2}$$

where λ is wavelength of incident light.

The optical dispersion of SiO₂ obeys [S2]:

$$n^{2} = 1.286 + \frac{1.0704\lambda^{2}}{\lambda^{2} - 0.01} + \frac{1.102\lambda^{2}}{\lambda^{2} - 100}$$
(S3)

From Fresnel law, we can obtain the following relationship:

$$t_{12} = \frac{2n_1}{n_1 + n}, \ t_{23} = \frac{2n}{n_2 + n}, \ r_{21} = \frac{n_1 - n}{n_1 + n}, \ r_{23} = \frac{n_2 - n}{n_2 + n}$$
 (S4)

 t_{12} is amplitude reflectivity from air to SiO₂, t_{23} is the amplitude reflectivity from SiO₂ to TiO₂, r_{21} is the amplitude reflectivity from SiO₂ to air, and r_{23} is the amplitude reflectivity from SiO₂ to TiO₂. The transmission enhancement of the SiO₂ incorporated TiO₂ photoanode after repeated reflection and transmission can be calculated according to:

$$T = \frac{(t_{12}t_{23})^2}{1 - 2r_{21}r_{23}\cos\varphi + (r_{12}r_{23})^2}$$
(S5)

T represents transmission, $\varphi = \frac{4\pi}{\lambda} d \cos \theta$ is phase difference, *d* is the thickness of SiO₂, θ is the angle of incident light. In our experiment, the DSSCs are illuminated perpendicularly by the simulated solar, therefore, θ is 0°. After simulation by a programe, we find that the theoretical fitting and the experimental curve match well in the photoanode from 7 wt% SiO₂ incorporated TiO₂ nanocrystallines.

Supporting program

clear all

close all

lamada=linspace(0.29,1.05,1000);

n1=1*linspace(1,1,1000);

n=1*(1.286+1.0704*lamada.^2./(lamada.^2-0.01)+1.102*lamada.^2./(lamada.^2-100)).^0.5;

 $n2{=}0.5{*}(5.913{+}0.2441{.}/(lamada.^{2}{-}0.0803)).^{0.5}; \ \%, \ 0.5$

d=1e-6; %

```
fy=4*pi./(lamada*1e-6).*n*d;
```

t12=2*n1./(n1+n);

t23=2*n./(n+n2);

r21=(n1-n)./(n1+n);

r23=(n2-n)./(n2+n);

%R=((n1-n).^2.*(cos(fy/2)).^2+(n1.*n./n2-

 $n2).^{2.*}(\sin(fy/2)).^{2)}./((n1+n).^{2.*}(\cos(fy/2)).^{2+}(n1.^{n./n2-n2}).^{2.*}(\sin(fy/2)).^{2});$

 $T = (t12.*t23).^{2}./(1-2*r21.*r23.*cos(fy)+(r21.*r23).^{2});$

plot(lamada,n)

figure

plot(lamada,n2)

%figure

%plot(lamada,n)

T1=T*100;

lamada1=lamada*1000;

figure

plot(lamada1,T1)

Supporting figures



Figure S1. Photovoltaic characteristics of six randomly selected TiO₂/SiO₂-(ii) based DSSCs.

Supporting references

- [S1] J. R. Devore, Refractive indices of rutile and sphalerite. J. Opt. Soc. Am. 41 (1951) 416.
- [S2] G. Ghosh, Dispersion-equation coefficients for the refractive index and birefringence of calcite and quartz. Opt. Commun. 163 (1999) 95.