

Supplementary Information

Light Coupling and Trapping in Ultrathin Cu(In,Ga)Se₂ Solar Cells Using Dielectric Scattering Patterns

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Absorption properties of the TiO₂ nanoparticles

Figure S1 shows the real (a), η , and imaginary (b), κ , part of the refractive index of the TiO₂ particles used in the experiment, which was determined by ellipsometry on a flat layer, deposited in the same evaporator and using the same evaporation procedure as for the nanoparticles. TiO₂ shows a high real part of the refractive index (a), which leads to the strong scattering by the nanoparticles, combined with a low imaginary part (b), which leads to the very small optical losses. In the UV spectral range κ becomes significant, but in this range the CIGSe cells demonstrate low photocurrent anyway due to strong parasitic absorption in AZO/ZnO/CdS layers and low intensity of the AM1.5 spectrum. Therefore the AM1.5 averaged absorption losses in the TiO₂ nanoparticles are very small.

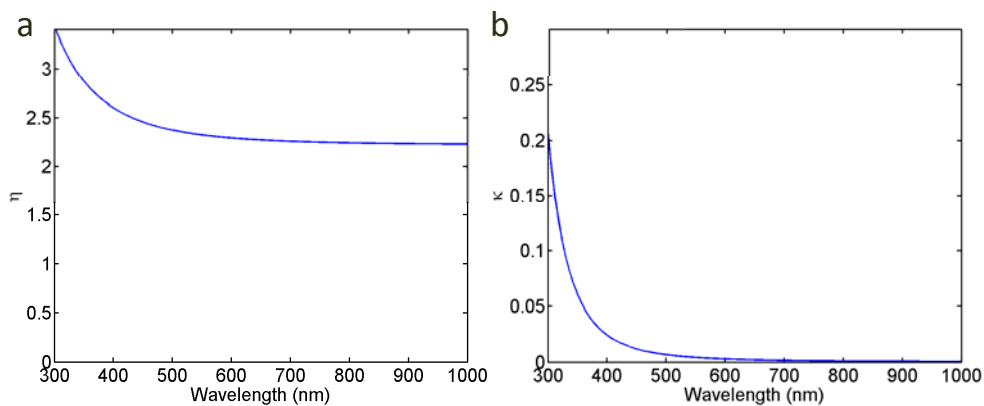


Figure S1. Experimentally determined refractive index of TiO₂ material used for the front patterning. (a) shows the real part, η , and (b) the imaginary part, κ .

Effect of roughness on light absorption in CdS and CIGSe layers

Figure S2 shows FDTD simulations of absorption in the CdS and CIGSe layers for a flat layer stack (dashed) and layer geometry with roughness (continuous) as in the SEM cross section in Fig. 2. Simulations were done using interface profiles as taken the SEM data. Interface roughness leads to reduced absorption in the CIGSe layer in the blue spectral range, which is caused by additional absorption in the CdS layer. The absorption in the CIGSe layer in the red spectral range shows the same overall trend for the two geometries, but with slightly different modulations with wavelength.

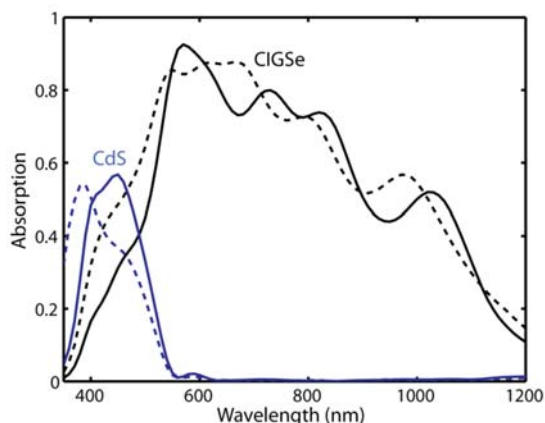


Figure S2. The influence of roughness at the CIGSe/CdS and CdS/i-ZnO interfaces. Continuous lines show the absorption in the CIGSe (black) and CdS (blue) layer with the roughness at these interfaces; dashed lines show the data for the same cell geometry without the interface roughness.
