Three-Dimensional (3D) Subwavelength-Thick Plasmonic Nano-Tiles on Terraces: Broadband, Omni-Angle, Near-100% Light Trapping and Absorption, Fabricated by a Single Nanoimprint Step over a Large Area

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Conventionally, near-100% light absorption in a material requires the material thickness larger than the light wavelength, often many times larger. Hence, a new material capable of near-100% absorption using a subwavelength thickness is not only intriguing, but also technologically significant to many applications, such as high-efficiency photovoltaics, thermophotovoltaics, solar desalination, and biosensors. In this work, we propose and experimentally demonstrate (a) a new type of 3D nanoplasmonic light-trapping/absorbing structure, termed "plasmonic nano-tiles on terrace" (PlaNTT), which absorbs light near 100%, broadband, high-efficiency, and omni-angle acceptance (nearly angle and polarization independent), with a thickness only 1/10 to 1/2 of the light wavelength; and (b) a simple, low-cost method of manufacturing such 3D structures over large-area by one-step nanoimprint.

For a total 210 nm thickness, the fabricated PlaNTTs exhibit >90% absorption (< 10% average reflectivity over a spectral range of 400 – 1100 nm and over a wide incident angle range (0 – 60 degree) for unpolarized white light. For p-polarized light, the average reflectivity of PlaNTT is as low as 0.8% over 400 – 700nm, and 3% over 400 – 1100 nm, which are the lowest reported values for thin-film plasmonic light trapping device for such broad spectral ranges.

The fabrication used on a single step nanoimprint of 3D nanostructures over entire on 4" wafer and is scalable to roll to roll manufacturing. The designs, fabrications, and findings should have many applications in photovoltaics, thermophotovoltaics, ultrasensitive photodetectors, and biosensors.

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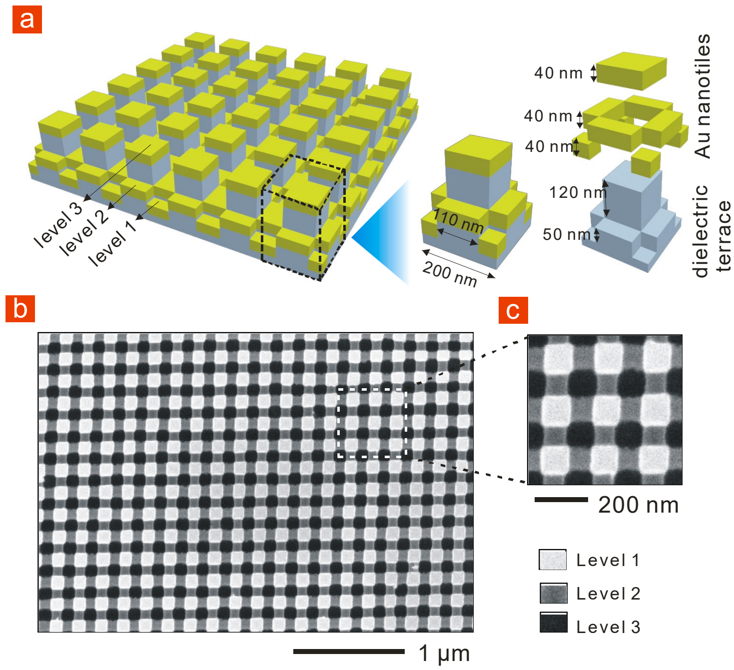

Figure 1. Tri-level Plasmonic nano-tile on dielectric squared nano-terrace array. a. Schematic drawing of the TPTT structure. b. Scanning electron micrograph of a typical TPTT structure fabricated by using the nanoimprint technique. c. Zoom-in look of the area labeled in b.

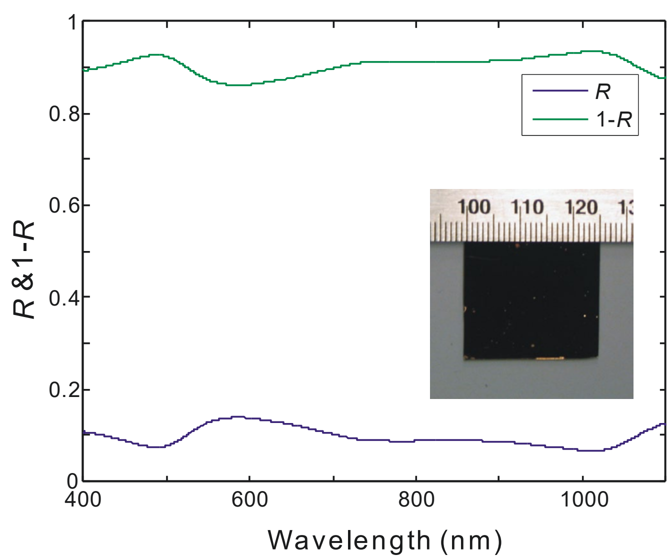

Figure 2. Broadband light trapping by imprinted PlaNTT over a 1" area. Measured reflectivity *R*, and extinction (1-*R*) spectrum of a fabricated TPTT sample with the normal incident angle. The inset shows a 1" × 0.9" sample under incandescent lamps. The sample exhibit black uniformly over the whole sample area.