Abstract: This talk summarizes our most recent advances in developing antimicrobial/biocidal materials that function through a light frequency amplification process called upconversion (UC). The first approach is based on inorganic luminescent materials doped with lanthanide activators that can convert visible light into germicidal UVC to inactivate microorganisms deposited on dry surface and deter biofilm formation under commercial fluorescent light exposure. UC efficiencies of current phosphor systems are too low for practical application. Approaches to enhance the efficiency of phosphors and to realize environmental remediation applications will be presented. The second UC approach is based on the mechanism of sensitized triplet-triplet annihilation (TTA) in an organic matrix. In TTA-UC process, a sensitizer excited by absorbing a photon with lower energy transfers absorbed energy to an acceptor/annihilator through triplet–triplet energy transfer (TTET), and two excited acceptors subsequently undergo TTA, emitting an upconverted singlet fluorescence with higher energy. TTA-UC in aqueous phase applications has been limited because it typically employs organic and metalloorganic chromophores that are soluble only in organic solvents. Moreover, to prevent triplet-state quenching, the medium must be devoid of oxygen, which is difficult to achieve in practical aqueous-phase scenarios. Strategies including micro-encapsulation to avoid oxygen quenching and sub-bandgap sensitization of semiconductor photocatalysts for advanced oxidation will be presented.