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Keynote lecture

RADIATIVE COOLING: FROM NANO-SCALE TO CITY SCALE

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Radiative heating and cooling are critical for thermal management of many electronic devices and operations, industrial processes, for buildings and, at much larger scales, for regions and cities. Lack of effective cooling of structures, from electronic equipment to buildings, is one of the most crucial bottlenecks towards energy efficiency efforts. The task is definitely complex and interdisciplinary as it requires advanced material studies to tailor their spectroscopic response to the desired outcome. At nano-scale level, it involves structuring of surfaces to utilize plasmonic interactions. With the improved understanding of plasmonic behavior of materials, surfaces with different spectroscopic and geometric characteristics can be designed and constructed to tune the spectral absorption, emission and reflection/scattering characteristics of surfaces. Once the desired properties are available, radiative cooling of structures can be achieved and thermal energy management can be optimized to have higher level of energy conservation. However, these approaches are usually expensive and require significant know-how.

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In this presentation, we will review the literature for radiative cooling and outline the recent developments in materials and structures. We will discuss the impact of these advances on the effective use of radiative transfer calculations for far- and near-field energy transfer practices. We will discuss the the use of electromagnetic wave theory towards formulating near-field radiative transfer (NFRT) as it is needed for the calculation of spectral, directional as well as near-field features for applications to new devices and processes. Accurate and fast numerical simulations of NFRT with the desired radiative properties of surfaces and structures are crucial for the technology to reach maturity and to be used extensively. Consequently, along with the developments of the theoretical and physical basis of near-field radiative transfer, new numerical techniques need to be developed for the solution of governing equations. These numerical studies will also be highlighted. The presentation will finally focus on the review of other materials to be used at larger scales, from buildings to industrial systems.