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Vacuum Insulation and Smart Coatings for Net Zero Energy Buildings: Current Status and Future Prospects

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ABSTRACT

The perception at which, nowadays, net zero energy buildings (NZEBs) cannot be imagined without glass is because glazed windows play an imperious role of allowing natural daylighting, but with repercussion of space-heating energy loss in cold-arid and space-cooling energy loss in hot-arid areas. As such, evitable energy losses through glazed windows of NZEBs indirectly contributing to carbon emissions and, thus, impelling climate change. This is, predominantly, due to an inadequate thermal transmittance value (U-value) of a glazing and not use of progressive coating technologies. This talk aims to present the novel constructions and performance characteristics of the advanced smart vacuum insulation technologies with semi-transparent photovoltaic and electrochromic coatings for NZEBs that are: (i) Vacuum Glazing (VG), (ii) Triple Vacuum Glazing (TVG), (iii) Electrochromic Vacuum Glazing (EVG), (iv) Semi-transparent Photovoltaic Electrochromic Vacuum Quadruple Glazing (STPV-EVG), (v) Translucent Vacuum Insulation Panel (TVIP), and (vi) Fusion-sealed Vacuum Glazing (FVG). The experimental results show VG achieved U-value of 0.97 $Wm^{-2}K^{-1}$, it was further reduced with TVG that achieved U-value of 0.33 $Wm^{-2}K^{-1}$. To control the solar heat gains from 0.41 (transparent mode) to 0.13 (opaque mode), ECG is constructed that achieved U-value of 0.82 $Wm^{-2}K^{-1}$, it required electrical power of < 0.4 Wm^{-2}. To make it self-reliant, the semi-transparent PV glazing was integrated to EVG to supply the power and store the generated energy using NiMH battery, the STPV-EVG achieved U-value of 0.79 $Wm^{-2}K^{-1}$. Due to the cost of hermetic glass edge-sealing materials, a new structured core transparent vacuum insulation panel (TVIP) is constructed, to accomplish insulation for the windows without edge sealing effects, that achieved U-value of 1.72 $Wm^{-2}K^{-1}$ but longevity of vacuum pressure is a challenge. The development of novel cost-effective fusion seal for the construction of fusion-sealed vacuum glazing (FVG) that achieved hermetic airtight vacuum seal with the U-value of 1.24 $Wm^{-2}K^{-1}$ is seemed to be the most low-cost solution for mass production.

Keywords: Electrochromic, Fusion Seal, Semi-transparent Photovoltaics, Vacuum Glazing, Translucent Vacuum Insulation Panel.