Smart Vacuum Glazing invented with Energy-Efficient Fusion Seal for the Solar Thermal Transmittance Control in Buildings

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KEYWORDS – Solar Thermal, Vacuum Glazing, Energy-Efficiency, Buildings, Thermal Transmittance.

ABSTRACT

Carbon footprint and energy efficiency of buildings are deemed to be the global concerns due to links with fuel poverty and climate change. There is also a solemn prospect of balancing the energy supply and energy demand. Smart vacuum glazing is a quintessential development in the move to energy-efficient buildings because of the solar thermal energy loss through conventional windows (such as double or triple glazed windows) in the cold-arid countries such as Russia, EU and UK. The reason vacuum glazing is smart is as it maintains the transparency, regardless of tiny pillar dots (0.13 mm high and 0.3 mm wide made of stainless steel allow), and its slim due its narrow vacuum gap (0.13 mm height) when compared to the conventional glazing. A vacuum gap essentially is a space, between two glass sheets, of reduced mass of atmospheric-air, thus air-density defines the level of the vacuum pressure. This provides solar thermal vacuum insulation, because with a lower density of air the mean free path between air molecules can be increased to above 1000 m, ultimately reduces the solar thermal flow between air molecules in a space. The space between two glass sheets is usually evacuated to high-vacuum pressure (0.13 Pa to $1.33{\cdot}10^{-4}$ Pa) in order to reduce conductive and convective thermal transmittance to marginal levels, however the solar energy transmittance through radiation can only be minimized using low-emittance coatings. In this paper the results of the experimental and theoretical investigations into the development of lead-free and ultrasonic soldering free fusion seal made of B_2O_3 surface textured layer and ultrasonically soldered with Sn90In10 alloy wire sealing the edges of the two glass sheets hermetically (named fusion seal) are reported. The glass sheets are separated by 0.13mm high and 0.3 mm diameter support pillars. A medium-vacuum pressure of the evacuated cavity between two glass sheets is achieved to be 0.095 Pa. Stress patterns were observed during the evacuation and the pump-out hole was sealed with improved method and composite, Cerasolzer-CS186 alloy. A three-dimensional finite-element model for this prototype was also developed. It was implemented on predicting the centre-of-glass thermal transmittance of fusion-sealed vacuum insulated glazing to be 1.039 $Wm^{-2}K^{-1}$, which is about five times less than the thermal transmittance of the conventional single glazing. The results show that the fusion seal is potentially a most cost-effective solution as compared to other sealing materials.