# A review of vacuum glazing and electrochromic vacuum glazing

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# Title: A Review of Vacuum Glazing and Electrochromic Vacuum Glazing

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## *Abstract*

**1. Vacuum glazing (project funded by UK EPSRC)**: To improve energy efficiency of a building, it is very important that all components of the building envelope provide good insulation. Usually the windows exhibit poorer thermal performance than other parts of the building envelope since the windows need to allow the sun light into the rooms and the occupants to view the outside. Heat loss through the windows occurs in three ways: conduction, convention and radiation. The most common approach is to use the multiple glass sheets with air or inert gas filling the gap between the glass sheets to reduce conduction and convection, with the low-emittance (low-e) coatings on the glass surfaces to reduce long wavelength heat exchange. However multiple glass sheets increase the weight and cost as well as reducing the light transmission. Vacuum glazing overcomes these difficulties. It comprises two sheets of glass having surfaces coated with low-e coatings, separated by a grid of support pillar arrays to counteract atmospheric pressure. The peripheral edges of the vacuum space are sealed by solder glass (melting point: 450 $^{o}$C) or indium sealant (melting point: less than 200 $^{o}$C). The low-e coatings reduce radiative heat exchange to a very low level and the vacuum space between the two glass sheets removes the heat conduction and convection. Using a low temperature indium sealing technique, the research group at the University of Ulster has successfully fabricated vacuum glazing samples with heat transmissions of 0.86 $W.m^{-2}.K^{-1}$. Since a large range of soft coatings and tempered glass will degrade at a high sealing temperature of 450 $^{o}$C, the indium based sealing technique has greater potential for application. A finite volume model was developed to calculate the thermal performance of vacuum glazing with various frames, low-e coatings, glazing size, glass thickness and solar insolation. Optimization of vacuum glazing design was theoretically and experimentally undertaken. A guarded hot box calorimeter was developed to characterise the thermal performance of vacuum glazing. Significant theoretical research and experimental work will be reported in detail in the full paper.

**2. Electrochromic (EC) vacuum glazing (project funded by European Commission)**: An EC-vacuum glazing consists of normal double glazing integrated with a third glass sheet coated with electrochromic film, which can control visual light transmittance when a 1-2V DC switching power is applied. The "EC vacuum glazing" combines an electrochromic smart window with a vacuum glazing. This provides both very low heat transmittance (less than 1 $W.m^{-2}.K^{-1}$) and optimal visible light transmittance whilst allowing control of solar gain and thus thermal comfort for the building occupants. It may reduce peak energy demands both for cooling during summer and heating during winter. A finite volume model was developed to simulate the thermal physical behaviour of EC-vacuum glazing. Simulations show that in a cooling-dominated climate, the inclusion of an EC window can enable a building to consume less energy by controlling visual light transmission and solar heat gain coefficient when compared to conventional double glazings. In a heating-dominated climate, an EC window does not improve energy performance since it should remain in its bleached state during the heating season. In a study of the effect of insolation intensity on the thermal behaviour of EC-vacuum glazing, it was found that to avoid intolerable overheating discomfort, the EC layer between the double vacuum glazing and the third glass pane must face the outdoor environment.

## *Biography*

Funded by the UK Oversee Research Student Award, Dr Yueping Fang received his PhD from the School of the Built Environment (SBE), University of Ulster (UU), UK in 2003. After his PhD, he has worked as a Research Fellow in the SBE UU. He has published a significant number of research papers on advanced glazing systems in peer-reviewed international journals and presented his research at many esteemed international conferences. His expertise includes finite element analysis for heat transfer through building envelopes, and nonimaging optic designs.