A Multilayered Structure of Smart Window for Energy Saving and Environmental Purification

Ping Jin, Gang Xu and Masato Tazawa
National Institute of Advanced Industrial Science and Technology (AIST)
2266-98 Shimoshidami, Moriyama-ku, Nagoya, 463-8560 Japan

This presentation describes a multilayer structure with precise optical control at the nanometer level, as a smart window for houses and buildings, showing multifunctional performance of energy saving, comfort and environmental purification.

Windows capable of regulating solar/heat transmission using chromogenic coatings for energy saving and comfort are called smart. Smart windows can be made using chromogenic materials as coatings. Among the smart windows with chromogenic coatings, a thermochromic one, characterized by an automatic solar and heat control upon environment temperature, has attracted much attention for the simplicity and high effectiveness. Vanadium dioxide (VO_2) is one of the most feasible materials for thermochromic window coatings. The crystal exhibits an abrupt semiconductor-to-metal phase transition at a transition temperature τ_c =68^{o}C, accompanied with sharp changes optically from transmitting to highly reflecting particularly in the infrared (IR). The transition temperature of VO_2 can be reduced to near the ambient by element doping, in which the doping with tungsten metal seems to be the most effective.

However, the conventional VO_2-based thermochromic window has problems which have been hindering the application. One is too low the visible transmittance due to the large absorption at near the visible region which is related with room lighting, and another is the low reflection at the far infrared for heat insulation.

We have recently developed a novel and multifunctional window consisting of a VO_2-based thermochromic film with use of selected antireflection (AR) coatings. Optical constants of the related materials, particularly the optical constants of the VO_2 film both at low and high temperature, respectively, were determined from ellipsometry. A multilayer structure was designed for the window, and precise calculations of the optical properties of the multilayer structure were done using the transfer-matrix method. Spectral transmittance and reflectance were theoretically produced, and the integrated properties (luminous and solar) were obtained by integration upon the relative standards. Structural optimization was done using a self-made computer program for the maximums of desired integrated properties which results in highest window performance.

Both theoretically and experimentally, the visible transmittance was greatly improved using TiO_2 as one of the AR layer for VO_2, and a highly improved IR reflection for heat insulation was achieved by applying a IR reflecting layer. The calculated results were confirmed with films deposited by magnetron sputtering followed by optical measurements with spectrophotometers.

With the newly developed window from AIST, multifunctional performances such as ultra violet cutting, automatic solar and heat control, highly heat insulation, simple structure, and possibly photocatalytic performance in addition are largely expected.

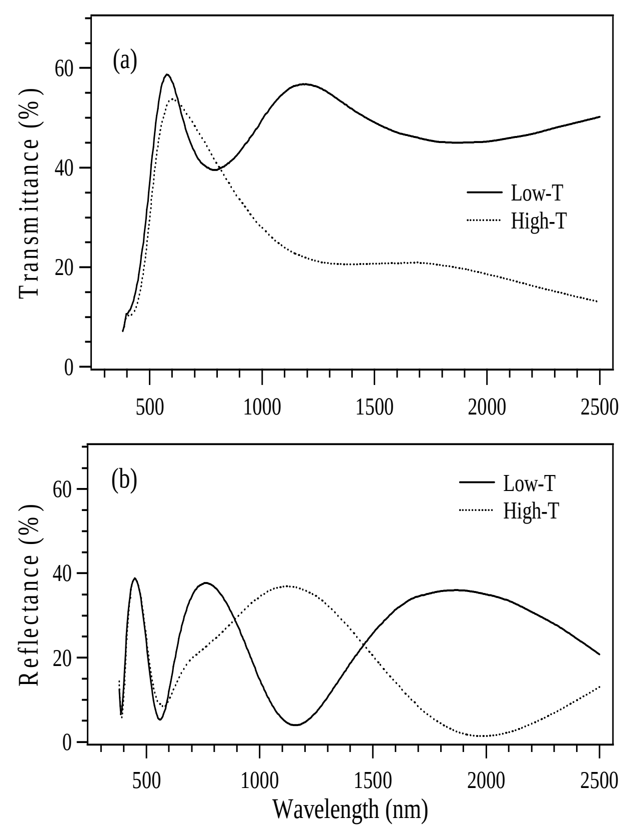

Fig. 1. Calculated spectral transmittance (a) and reflectance (b) of the window structure. Low-T is measured at 20^{o}C and high-T at 80^{o}C, respectively.