Thin film coatings for solar and thermal radiation control prepared by physical vapour deposition

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Thin Film Coatings for Solar and Thermal Radiation Control Prepared by Physical Vapour Deposition

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OUTLINE

• Introduction to energy-saving glazings
  • Metal-dielectric thin film coatings
  • Materials science of metal-dielectric thin-film systems
  • Solar control glazings: aims and challenges

• Physical Vapour Deposition (PVD) of metal-dielectric systems
  • Material properties and layer intercompatibility
  • Deposition methods and characterisation procedures
  • Manufacturability of designs optimized theoretically

• Experimental development and characterization results
  • Multilayer thin film structures – manufacture and properties
  • Main results achieved

• Conclusions
• **Energy saving glazings and optical coatings:**
  - Multilayer films on glass and radiation control
  - Cooling- and heating-related electricity savings
  - Solar control and low emissivity combination suits most climates

• **Enabling technologies and materials:**
  - Solar IR control through reflecting it back out
  - Thermal insulation improvements (Low-E glass)
  - Material combinations: TiO₂/Ag/TiO₂, WO₃/Ag/WO₃ etc.
  - New research is required to achieve better coating durability, higher visible transmission and spectral selectivity
Aims: to demonstrate advanced coatings on glass substrates which
- Block (selectively) most of the UV, solar IR (0.75-2.3\,\mu m) and thermal (2.5-40\,\mu m) radiations.
- Achieve high transmission (>80\%) in the visible range.

Materials science of metal-dielectric systems:
- Selection of appropriate materials - \(n(\lambda), k(\lambda)\)
- Ensuring optimum growth mode in ultrathin layers
- Preventing chemical reactivity
- Design of nanocomposite materials (or cross-contamination prevention)

Ultrathin metal layers can have different morphologies.
Optimisation of metal-dielectric multilayers

- Optilayer 8.85 software used

- **Dielectrics**
  - Oxides, nitrides sulfides and fluorides of refractive index from 1.38-2.4
  - Materials had high transparency across the entire visible range

- **Metal layers (Ag)**

- **Structures:**
  Glass/D\(_{(adh)_i}\)/D\(_1\)\_n/Ag/D\(_k\)\_l/Ag/D\(_x\)\_y(cover)

Single-Ag and triple-Ag designs were also trialled

Simulated spectral transmittance curves for different metal-dielectric multilayer thin film structures.
Coating production capabilities and deposition techniques

E-Beam and thermal evaporation

RF magnetron sputtering
Typical deposition conditions

- Glass substrates were not heated (at 20°C).
- Base vacuum pressures achieved in both deposition chambers were near $10^{-6}$ Torr.
- Layer growth rates were typically between 0.5-2.5 Å/s
- Ag layers were either sputtered or evaporated thermally
- Non-metallic layers were all E-Beam evaporated
- The argon (Ar) partial pressure used in RF sputtering chamber was between 1-2 mTorr.
- No O$_2$ input used – selected oxides with minimim O$_2$ loss
Experimental results – sputtered and evaporated metal-dielectric coatings on glass

Simulated and measured spectral transmittance curves for the optimized multilayer thin films
Experimental results – sputtered and evaporated metal-dielectric coatings on glass

Ultraclear/Clear glass substrates (left) and sputtered coatings on glass (right)

Evaporated coating on glass (200x200 mm)
In an insulated glass unit, when used as an intermediate coating, a very attractive combination of multiple energy-saving performance parameters results.

Evaporated large-area, stable metal-dielectric coatings for advanced glazing systems

Glazing performance calculations performed using LBNL’s WINDOW 6.3 software resulted in the following data set:

Main double-pane glazing parameters are

- Solar Heat Gain Coefficient (SHGC) = 0.46
- Visible Transmission VT = 72.9 %
- Relative Heat gain = 345 W/m²
- Thermal insulation U-factor = 1.639 W/(m²*K)

[Table showing detailed performance data]

http://windows.lbl.gov/software/window/window.html
CONCLUSIONS

- Thin film coatings suitable for solar+thermal radiation control were studied experimentally
- E-Beam, Thermal Evaporation and RF sputtering processes optimised for spectrally-selective metal-dielectric systems
- PVD parameters optimised for high quality thin films production, including the control over ultrathin layer properties
- Transparent and stable heat-mirrors designed and fabricated
Thank you

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