PREPARATION AND CHARACTERIZATION OF INDIUM DOPED TIN OXIDE COATED GLASSES AND ITS IR TRANSMISSION CONTROL PROPERTY

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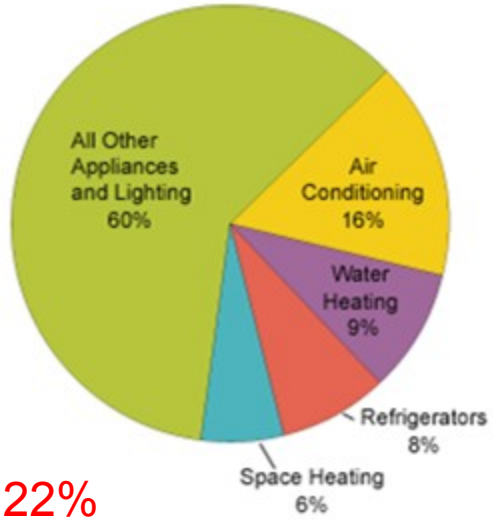
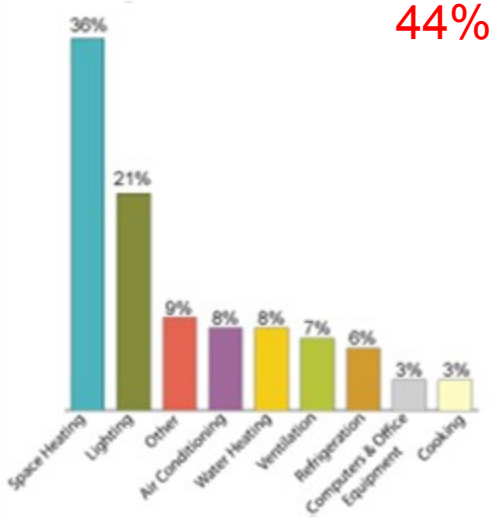
The trouble with cooling/heating places



22%

Source: US Energy Information Administration, Annual Energy Outlook 2010, Table 4, model results

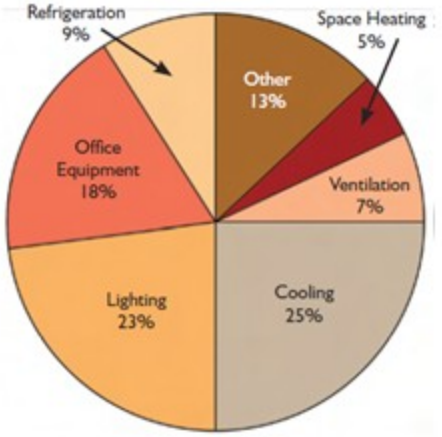
Figure 3a: Residential energy use data



44%

Source: US Energy Information Administration, 2003 Commercial Building Energy Consumption Survey, Table E1A (September 2008)

Figure 3b: Commercial building energy use



30%

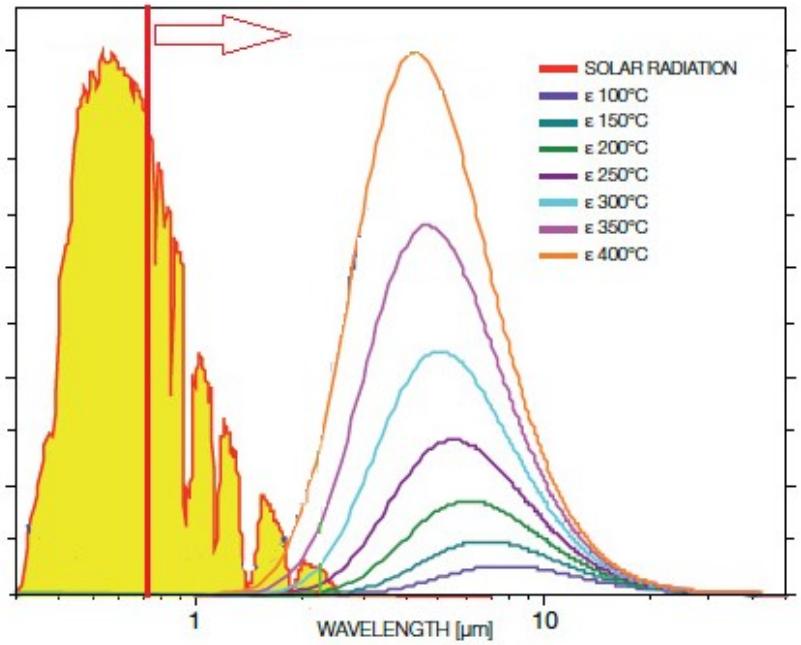
Source: Holmberg et al., BACnet for Utilities and Metering, ASHRAE Journal, April 2008

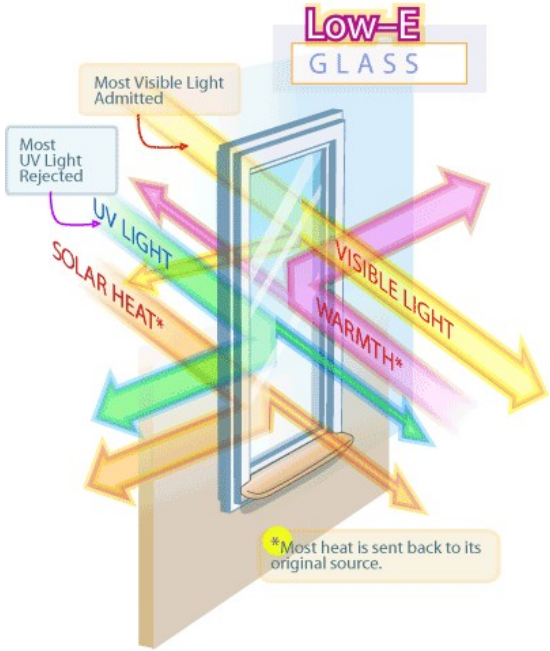
Figure 3c: Commercial electricity use

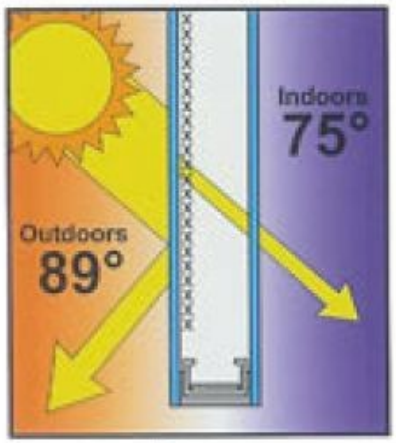
-Large component of energy is used for heating and cooling purposes in domestic and office environments

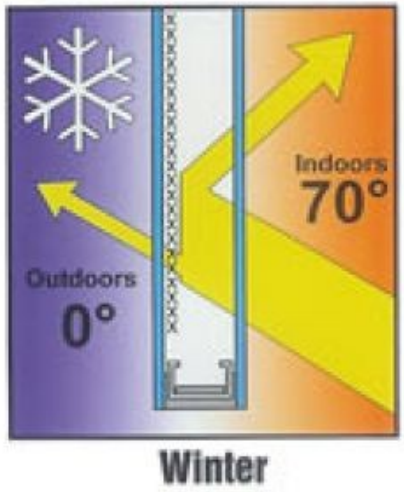
-In automobile interiors, largest component of heat penetration (72%) is through glasses

Energy and IR radiation









- Solar control coatings
  - Reduction of heat transmission through radiation is the key objective of solar control glasses
  - They can not only reduce heat transmission from ambient in hot days but also can prevent heat loss to ambient in cold days

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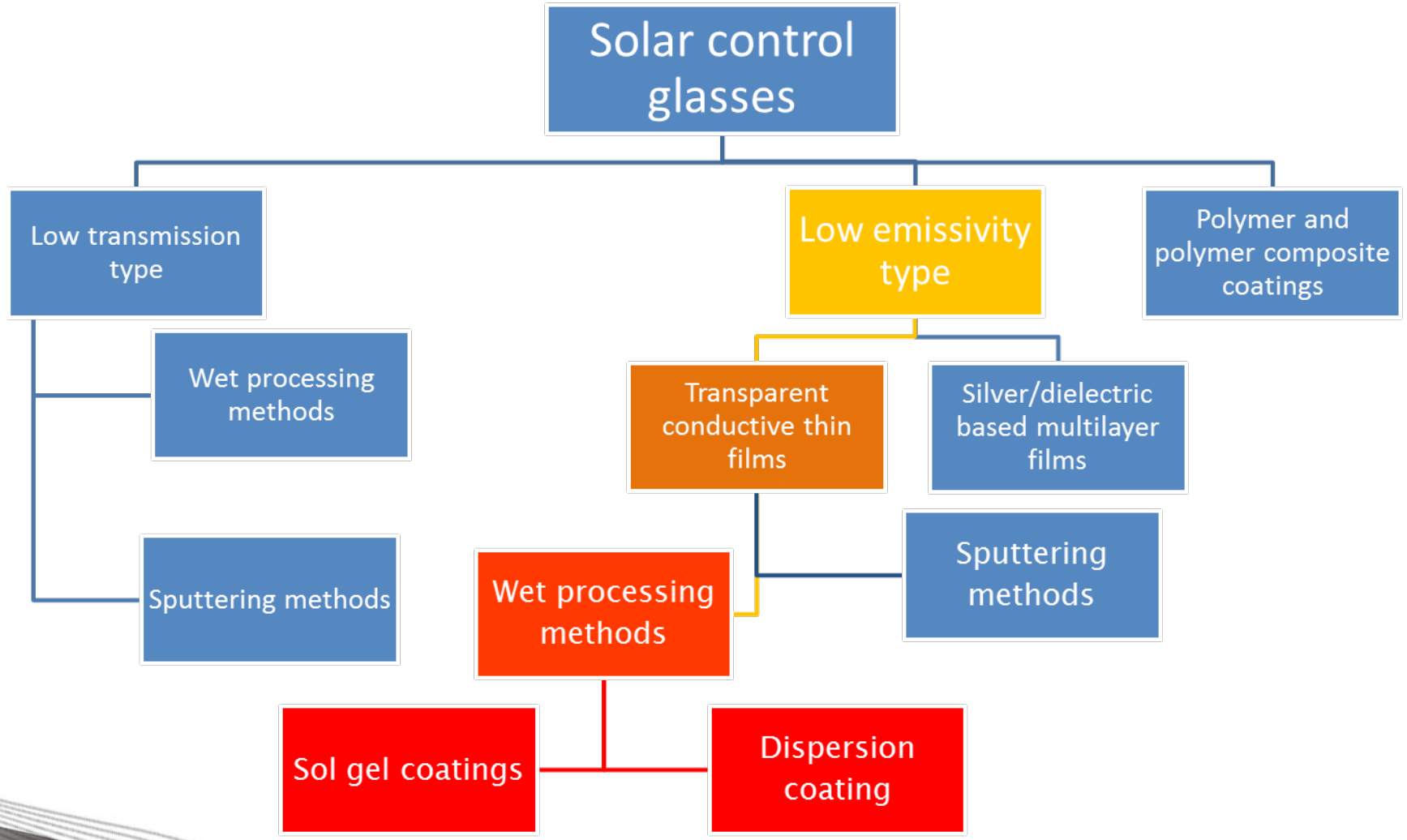
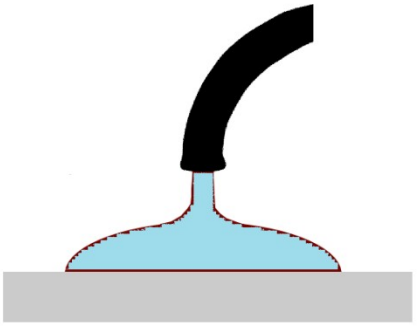
Available strategies



Dispersion based coating, importance

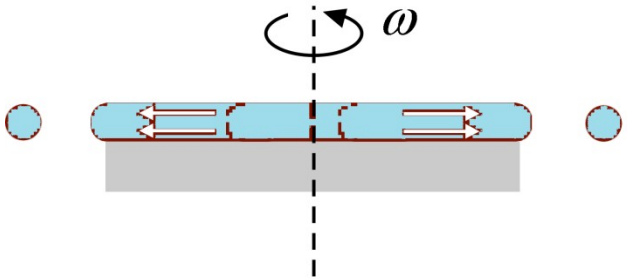
- Transparent conductive type solar control glasses are commonly prepared using sputtering methods
- The research focus on dispersion based coatings focusing on lower costs
- Challenges are
  - Higher conductivity
  - Higher uniformity
  - Less expensive materials
  - Industrially viable coating method

Solar control glass preparation



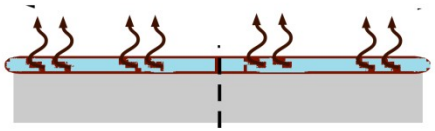
ITO concentration series

- 30%, 20%, 10% ITO (w/w) in isopropanol was prepared
- 1 mL of solution is dispensed in to 2.5 cm x 2.5 cm glass plate



Spinning speed(Film thickness)

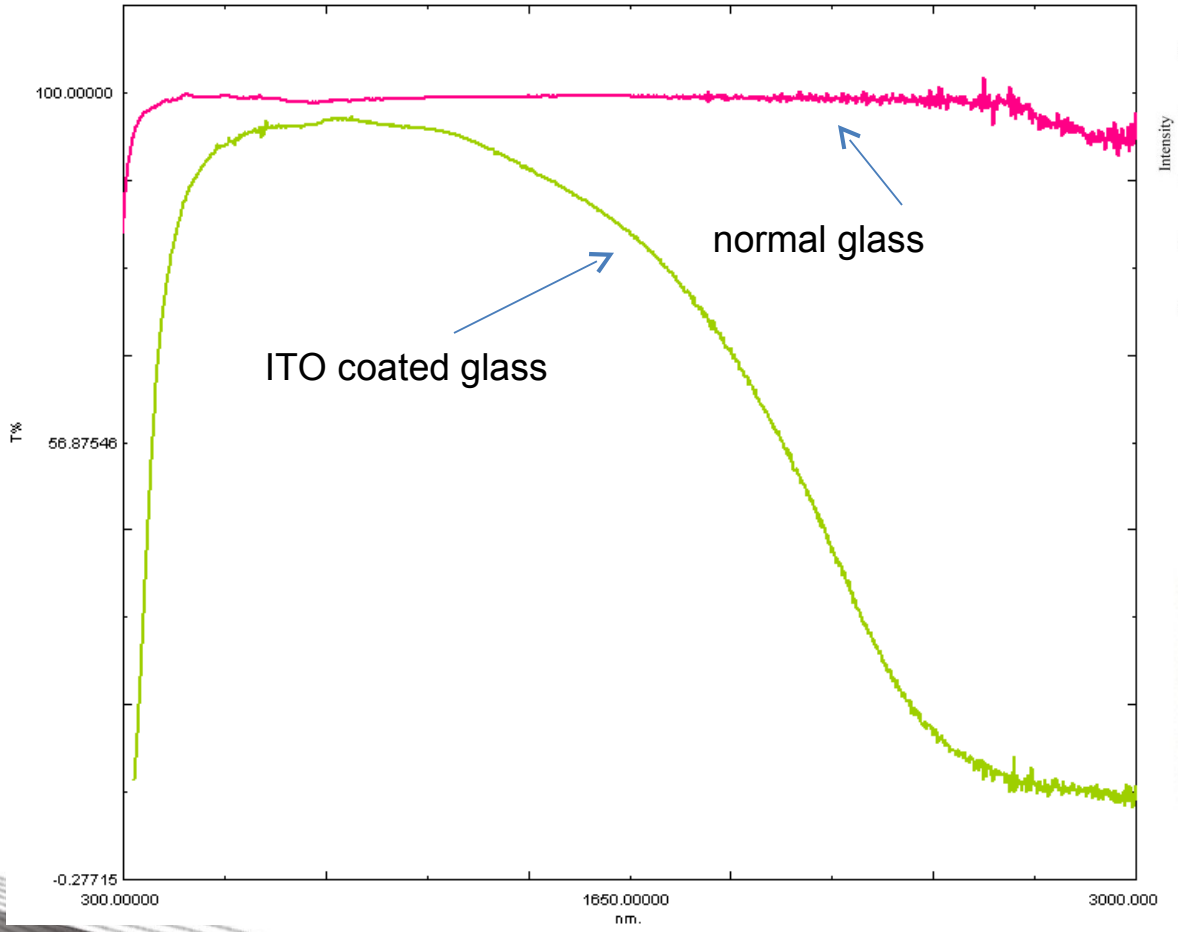
- Spinning speed was varied from 500 – 2200 rpm in 100 rpm intervals

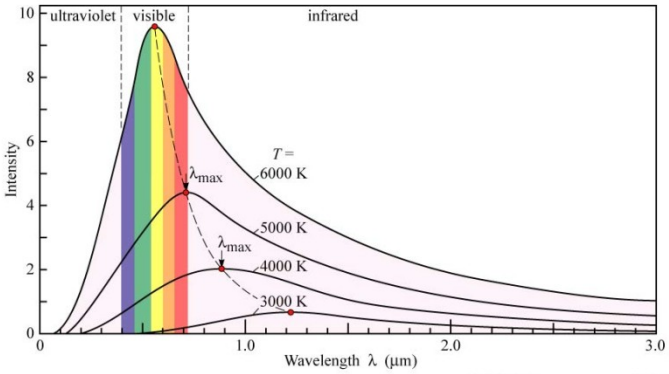


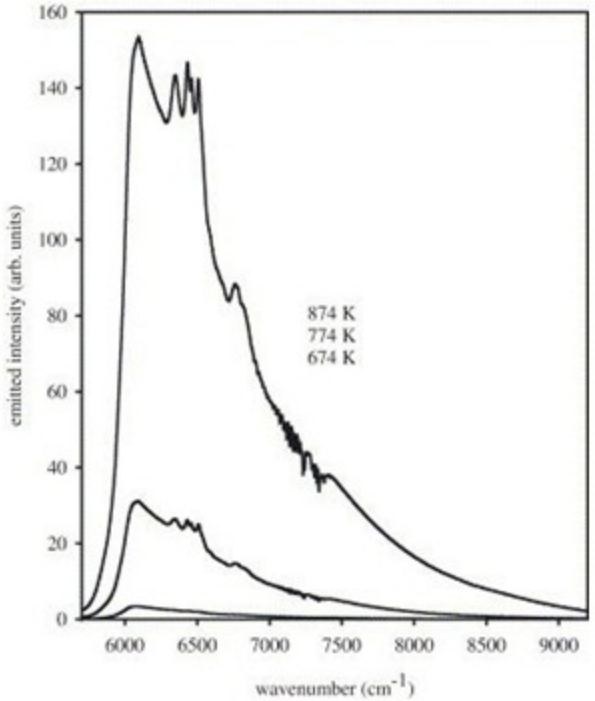
Firing conditions

-Currently held at 450^{o}C for 2 min

Transmission spectra

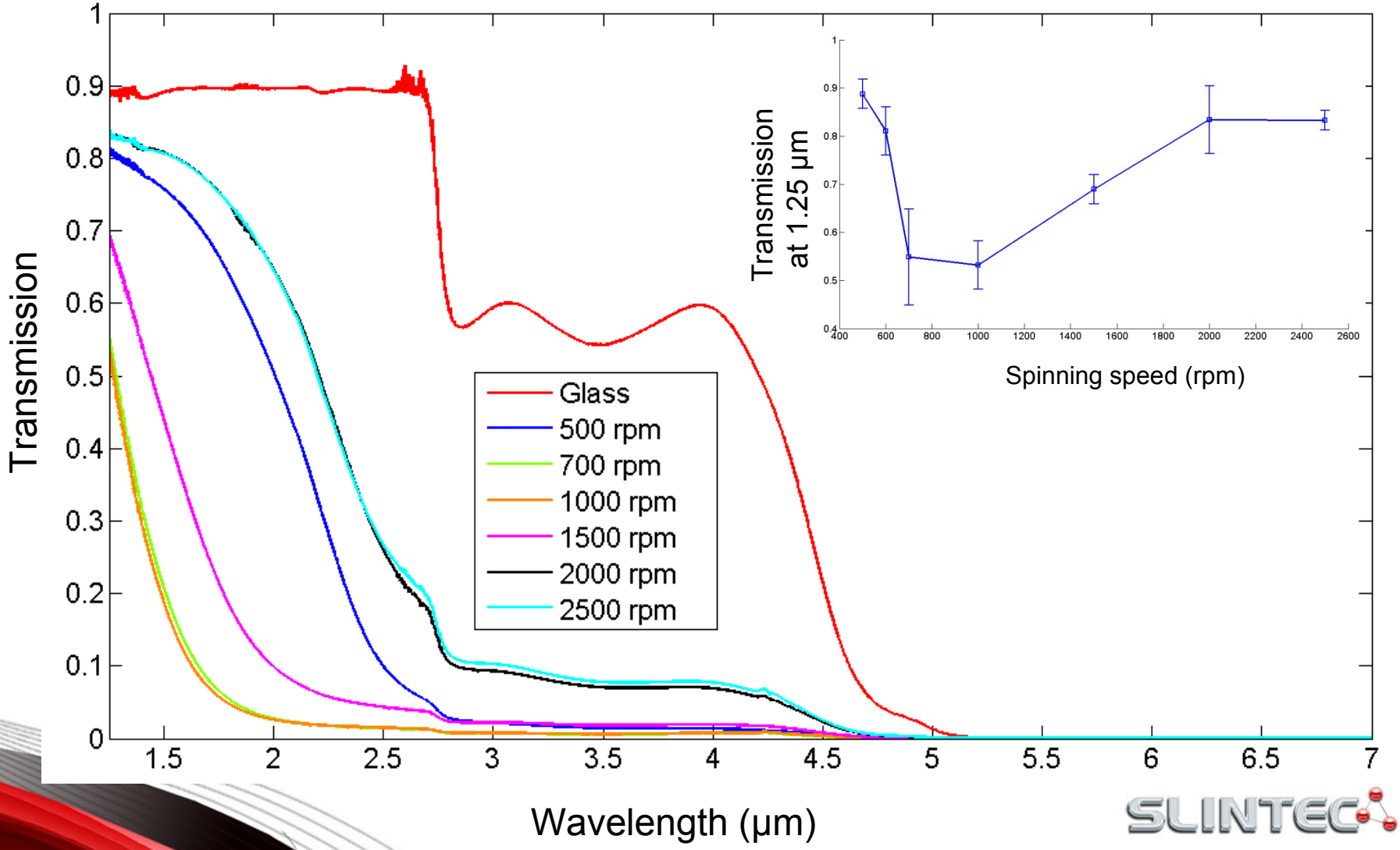




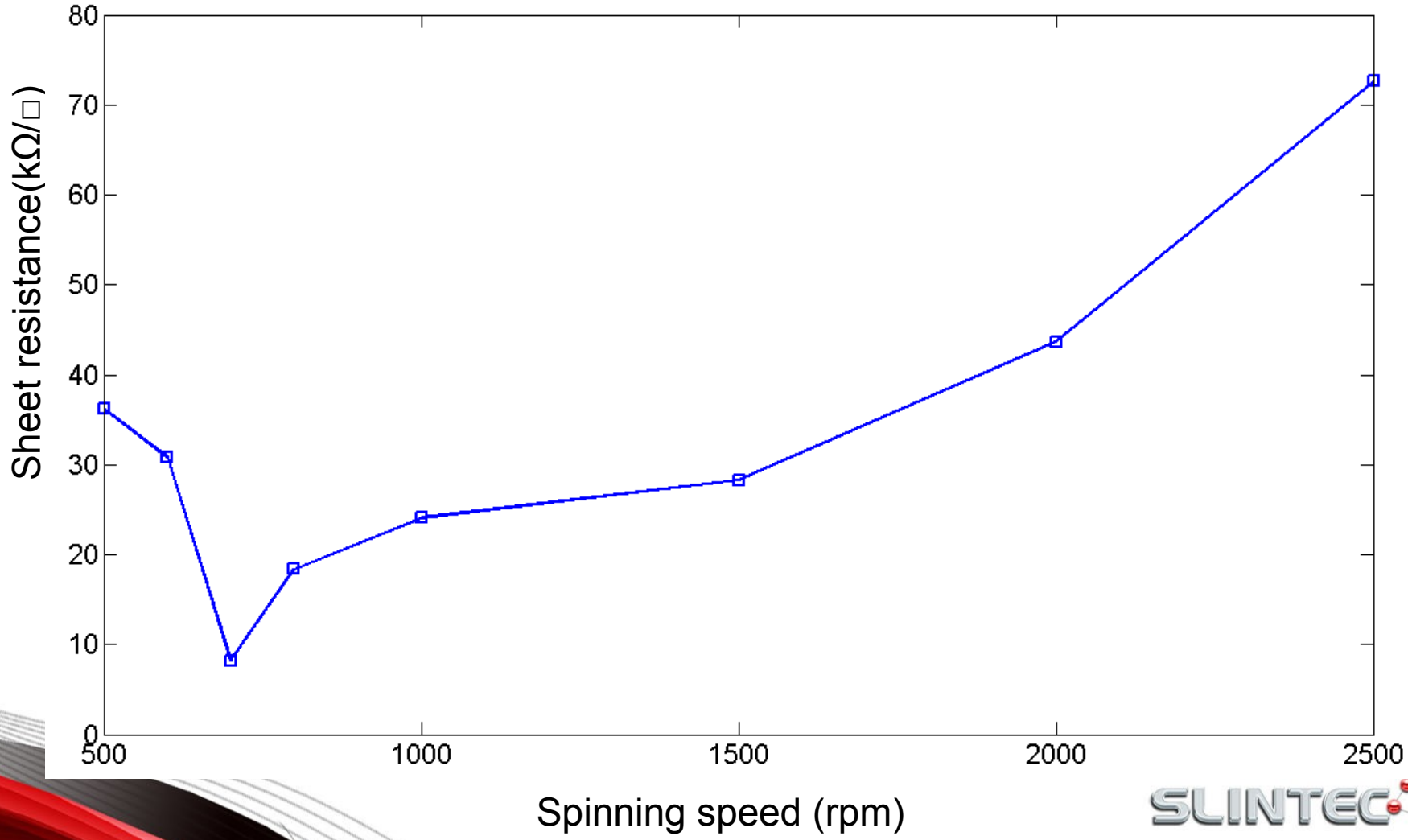


S. Wijewardane, D.Y. Goswami,A review on surface control of thermal radiation by paints and coatings for new energy applications,Renewable and Sustainable Energy Reviews, Volume 16, Issue 4, May 2012, Pages 1863–1873

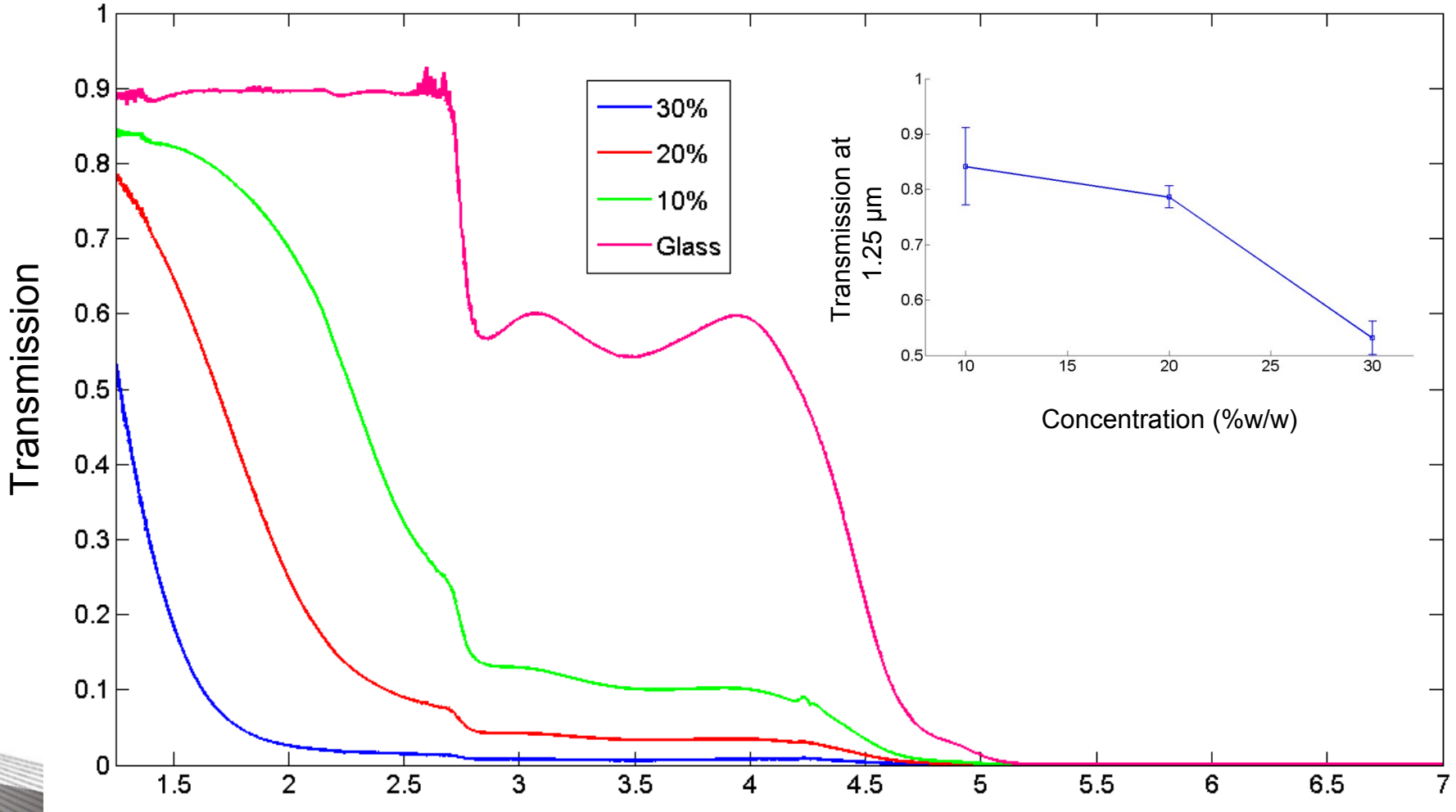
Transmission spectra with coating RPM



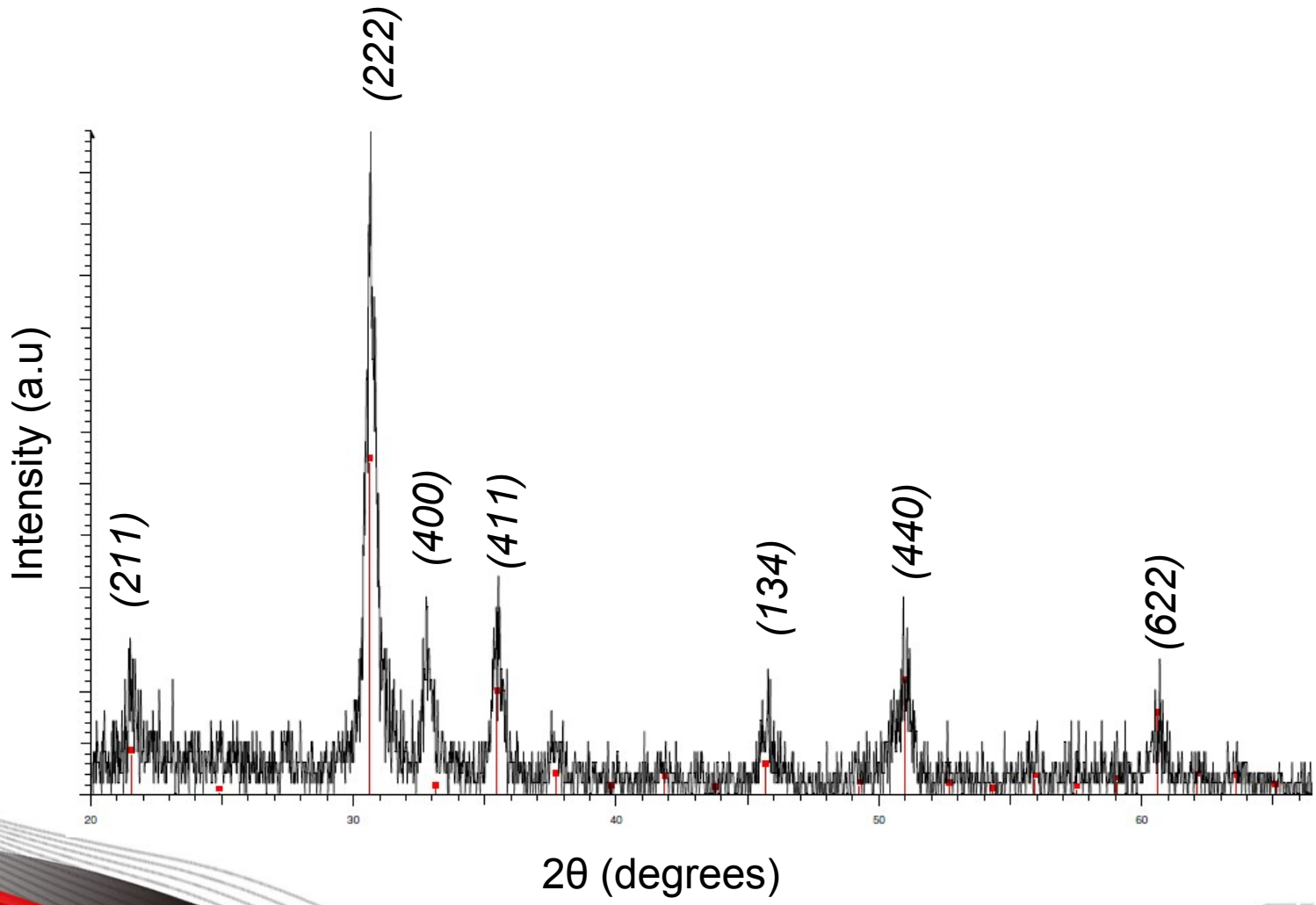
Sheet resistance with coating RPM



Transmission spectra with coating concentration

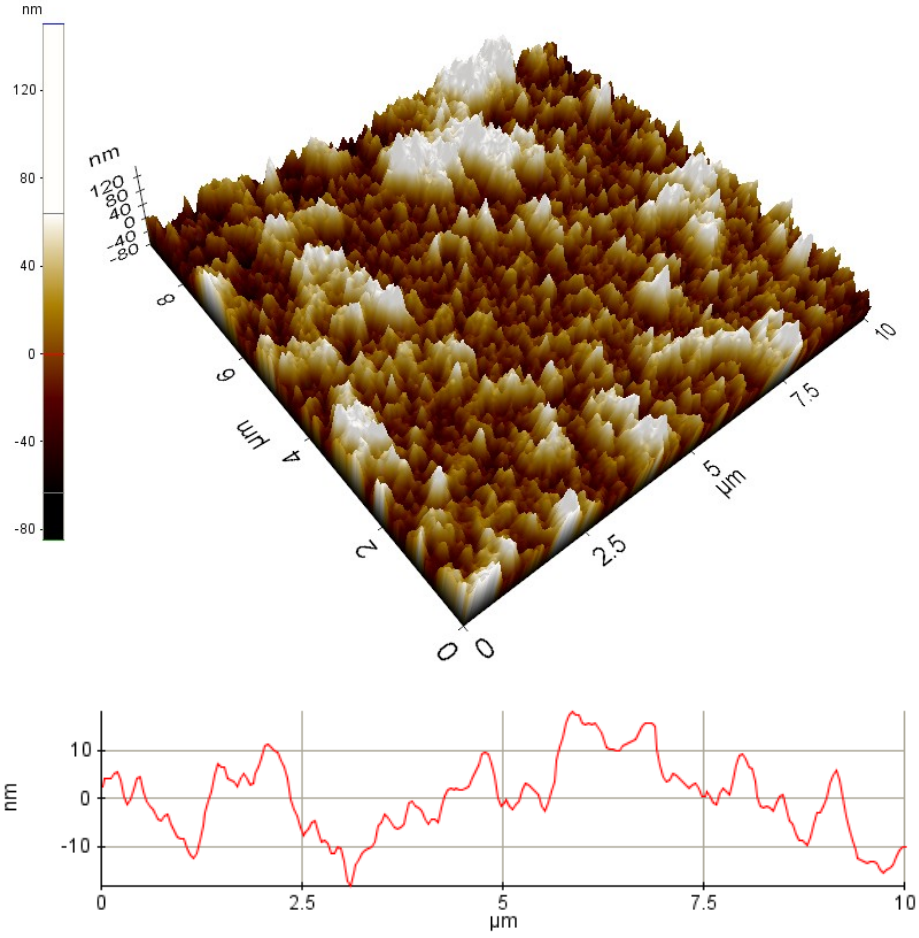


XRD analysis (Glancing angle)

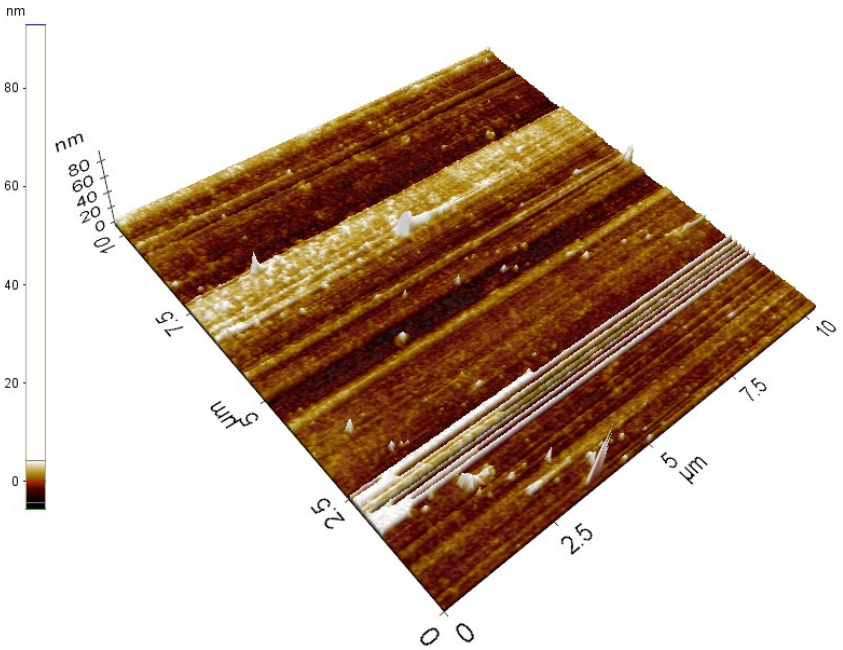


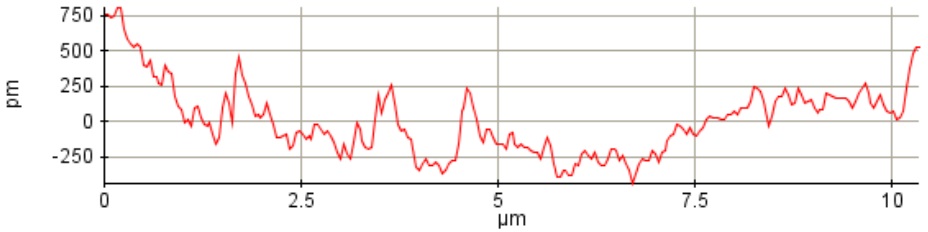
AFM analysis

ITO coated glass



Uncoated glass





Reason for IR reflectance

- The IR-reflective property of the transparent conductive thin films originate from the plasma formed by high concentration of electrons in the materials
- IR cutoff frequency is determined by

  $\omega_c = \omega_p(\varepsilon_i/\varepsilon_0 - 1)^{1/2}$
- Plasma frequency is determined by

$\omega_p = n_e e^2/[\varepsilon_0 m_e(\varepsilon_i - 1)] - \Upsilon^2$ where $\Upsilon = e/(m_e\mu)$

  - ω_p - Plasma frequency -
  - n_e-Electron concentration
  - m_e-Effective electron mass
  - μ-Electron mobility
  - ε_0-Permittivity of free space and ε_i= 3.85 is the dielectric constant at very high frequency
- Above suggests that the IR cutoff frequency can be lowered by increasing carrier concentration and/or electron mobility which results in lower resistivity

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Future work

- Preparation of IR reflective coatings with aluminum doped Zinc oxide thin films
- Preparation of distributed Bragg reflector type multilayer coatings to obtain selective transmission of light
- Further reduce IR cutoff wavelength for improved IR insulation property
- Characterization of hardness of the coatings