Biocidal Anti-Reflection Coatings

D.W.Sheel[1] H. Foster[2], P Sheel[3]

1: Materials Dept, Salford University, Manchester M4 5WT, d.w.sheel@salford.ac.uk, 2: BioSciences Dept , Salford Univ., 3: CVD Technologies Ltd ,

Summary

Anti-reflection coatings are finding increased application in areas varying from displays, architectural, and photovoltaics. In a number of application uses, there could be significant added value if the films also exhibited biocidal (and anti-fungal) properties. In this study we have deposited good performance AR coatings which show both these properties.

For commercial application, such coatings would need not only to exhibit sufficient biocidal and anti-reflection performance, but also and avoid introducing unacceptable levels of haze. Ideally the layer would also have low angular sensitivity. Furthermore, the chosen deposition technology would need to meet challenging cost targets and be capable of scaling to large areas and high throughput volumes.

Approach

In this work we have explored Flame Assisted CVD (FACVD) to achieve AR functionality and also biocidal functionality. The flame delivers activation energy to the precursor and reduces the substrate temperature needed (compared to thermal CVD and some sol-gel processes), to achieve fast growth and durability (to as low as 100C).

Experimental

The FACVD configuration is illustrated in fig 4. The system has been described previously (ref. 1).

The precursor (organosilanes) can be delivered as an aerosol or be pre-vapourised (via flash evaporation) depending on precursor employed. An antibacterial nano-structured metal precursor is incorporated into the gas mixture, or alternatively within an upper section of the film. Typical metals are silver and copper (ref.2). This mixture is then mixed with a flammable gas prior to being ignited. The flame energy activates the chemical reactions leading to deposition. The flame is located in contact with the substrate , and either the flame head or the substrate are moved to allow area coating.

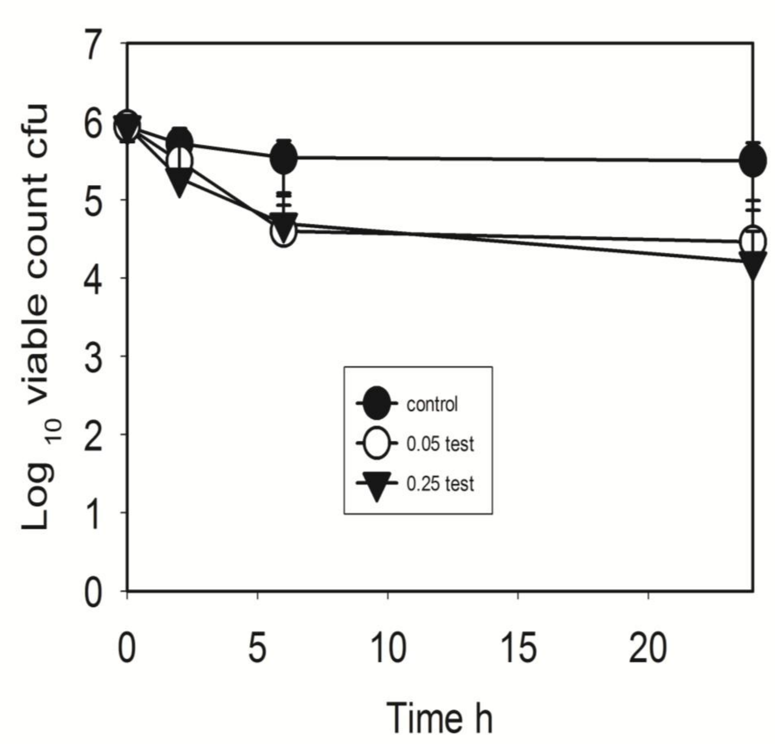

Fig 1 Biocidal activity of AR coating

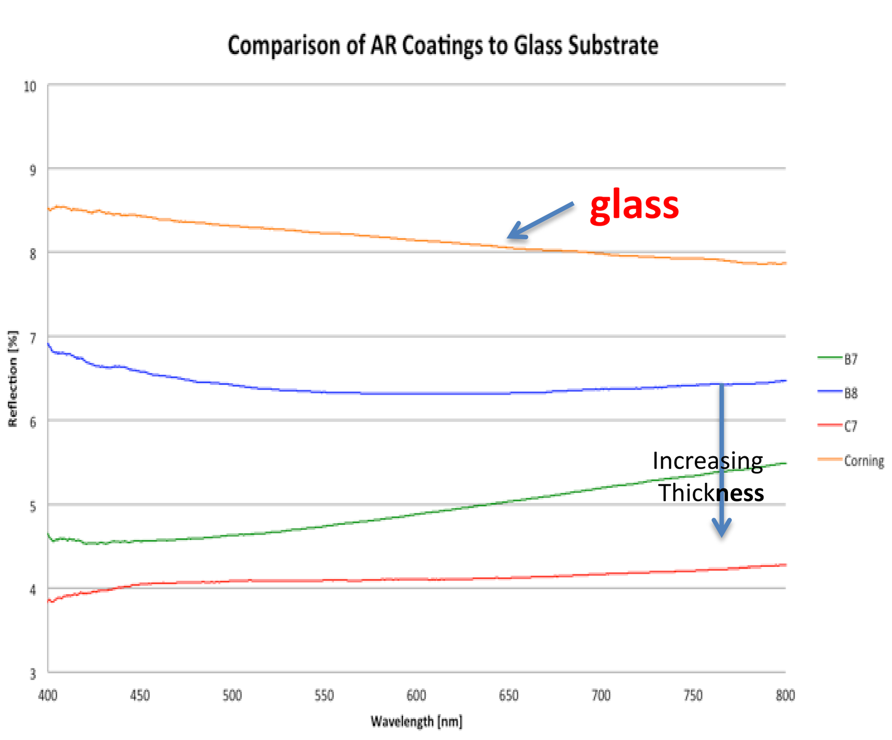

Fig 2 reflection AR on Glass increasing with AR film thickness

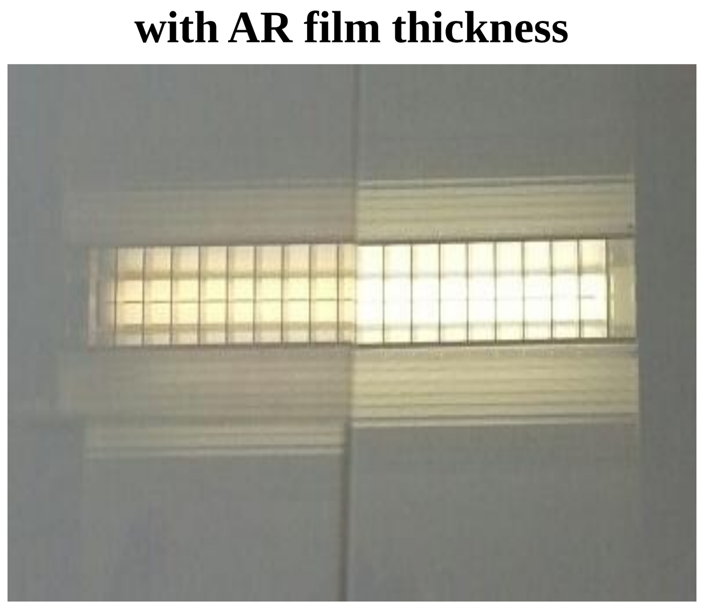

Fig 3 Refl. of light fitting – left side AR coated

Biocidal testing

Escherichia coli ATCC 8739 cultures were resuspended in Nutrient Broth (NB, Oxoid) and kept on Microban® beads (TCS Ltd Merseyside, UK) at –70°C. Prior to use, one bead was sub-cultured onto NA and incubated at 37°C for 24 h. Antimicrobial activity was tested based on BS ISO 22196:2007 except that glass covers were used rather than plastic and the test was done at 20-25°C rather than 35°C as specified in the test. Samples were removed after 0, 1, 2, 4, 6 and 24 h and immersed in 20 cm^3 of sterile Tryptone Soy broth (Oxoid) and vortexed for 60 sec to resuspend the bacteria. A viability count was performed by dilution and plating on NA in triplicate and incubation at 37°C for up to 48 h. TSB had previously been shown to inactivate any copper released from the surfaces. (ref 2)

Results

Very good AR performance has been achieved, even in a single layer coating (see fig 2 and table 1). This is achieved by producing a gradient Refractive Index structure. The resulting AR performance can reduce the normal glass reflection (of ~4%) to under 1%. Incorporation of sufficient biocidal nano-structured metal for good activity, reduced transmission by less than 1%.

The AR films (Fig 1) demonstrated approaching 99% kill of bacteria (E Coli) in 24 hours. **Faster/higher kill rates can be achieved with some re-balancing of other properties**

The bio-AR coatings are toughenable.

Process Technology

FACVD operates in open air and in this application uses low toxicity and low cost precursors. FACVD capital costs are also *relatively* low and the technology is scalable from small to very large substrates, and up to high throughput capable system (see fig 4). Example configurations would be installation above an in-line conveyor or onto a Float Glass production line. FACVD also offers *relatively* easy integration into customer production lines, and is compatible with in-line operation at atmospheric pressure. Target coating costs are <$ 0.5 m-2

The AR and bio-active layers can be deposited simultaneously or directly sequentially.

	Thickn. (AR) nm	Refl. % ----	Tran. -@500nm	Haze %	Colour a*b*L
Glass	0	4.1	92	0.0	29, 0, 0.7
AR Glass	90	0.5	95	0.1-0.2	
Bio AR Glass	90	1.5	94.5	0.1-0.2	30,0.2,0.8

Table 1: results comparison - One surface coating

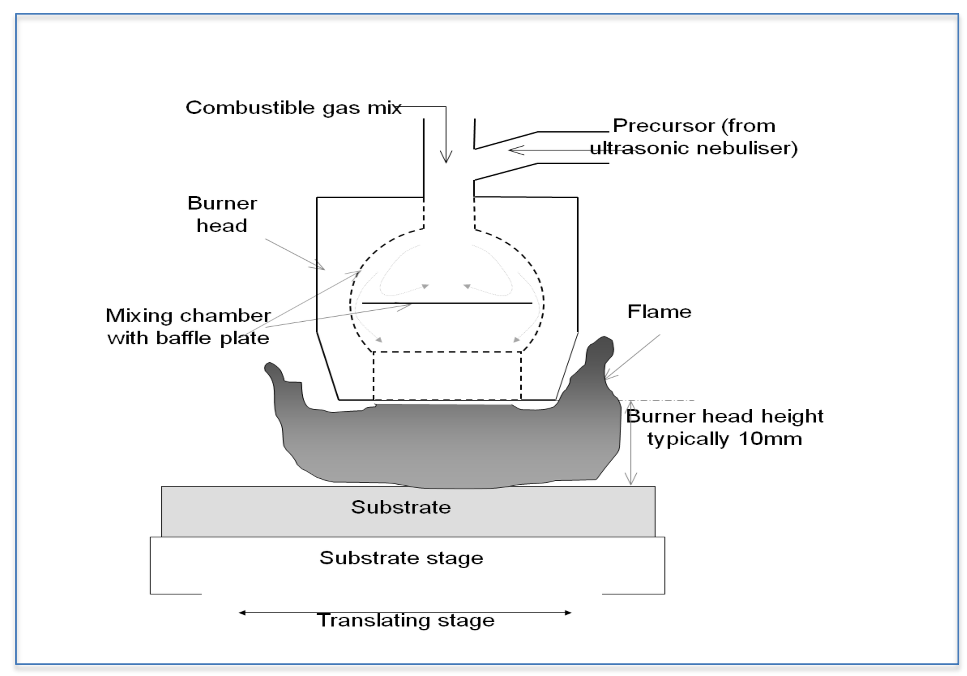

Fig 4 Schematic of FACVD operation

Fig 5 Laboratory In-Line coating by FACVD

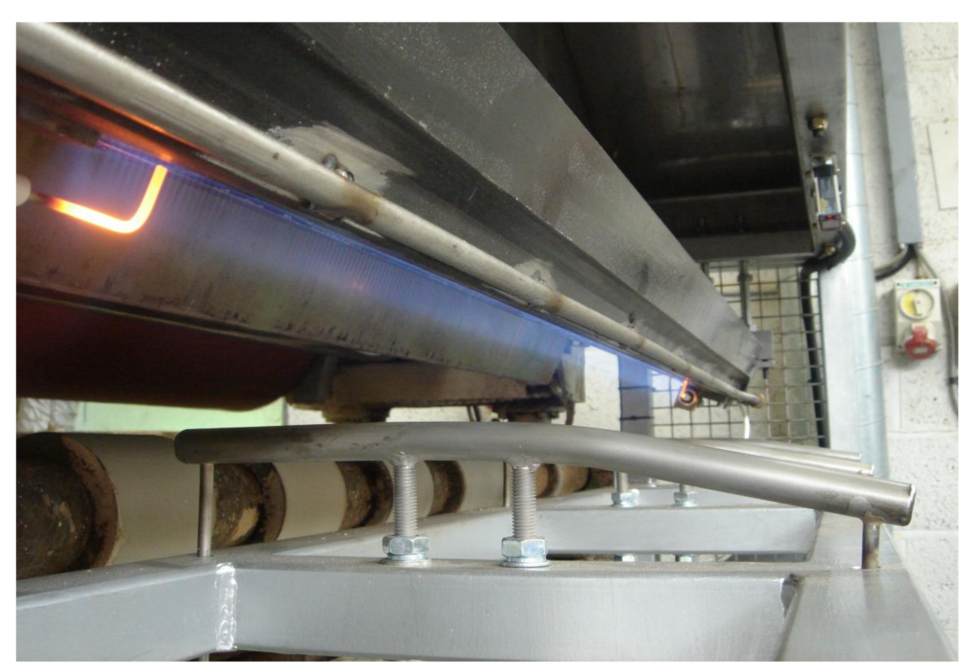

Fig 6 Large Scale Flame Surface Treatment Technology

Acknowledgements

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References

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2. AMB Express, 2013 Sept1 (53)

Way Forward

The company is now seeking collaborator(s) to pilot the technology. A patent has been filed.

Contact : Dr David Sheel
david.sheel@cvdtechnologies.com