The use of humidity sensors to develop BIPV packaging solutions

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Background

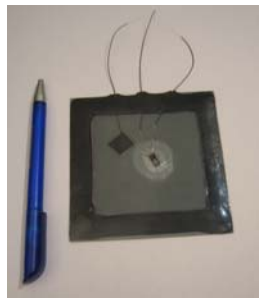
As a manufacturer of coated steel and cladding systems, rather than photovoltaic cells, an approach that allowed the development of encapsulation systems somewhat independent of cell technology was required.

A selection of indicators, from simple colour-change capsules to electronic sensors to measure relative humidity levels have been reported elsewhere, and humidity sensors are already utilised in the measurement of water vapour transmission rates for encapsulants (ISO 15106).

Subsequently, we have routinely utilised humidity sensors as a proxy to working cells in order to screen a wide range of encapsulants, films and sealants in addition to coated steel cladding systems and lamination process settings.

Procedure

Firstly, individual humidity sensors (Honeywell 4000 series) were calibrated by recording sensor voltage and ambient relative humidity (RH) in both the dry (<5%RH) and wet (c.55% RH) laboratories. A linear relationship between output voltage and RH is stated in the technical literature of the sensors.



Samples were then prepared in the dry laboratory for consistency. A sample size of 100x100mm was chosen, as sufficiently meaningful for larger modules, albeit with a greater ratio of perimeter to surface area. Colorcoat Prisma® (coated steel) was used as the backsheet in all cases, together with various polymer barrier film frontsheets and differing butyl edge seals. The 10mm butyl perimeter seal was sealed using a heated press at 30psi and 140°C for 30 seconds.

Later experiments also included an encapsulant as part of a more complete solution.

Damp heat testing was conducted in line with conventional protocols (85°C/85%RH) in a Design Environmental Alpha 190-40H chamber, with samples measured periodically.

Results

After some early sample failures associated with poor workmanship, a series of experiments were undertaken, focussing on particular material sets. As confidence in the test procedure grew, exposure times were extended beyond the basic test standards.

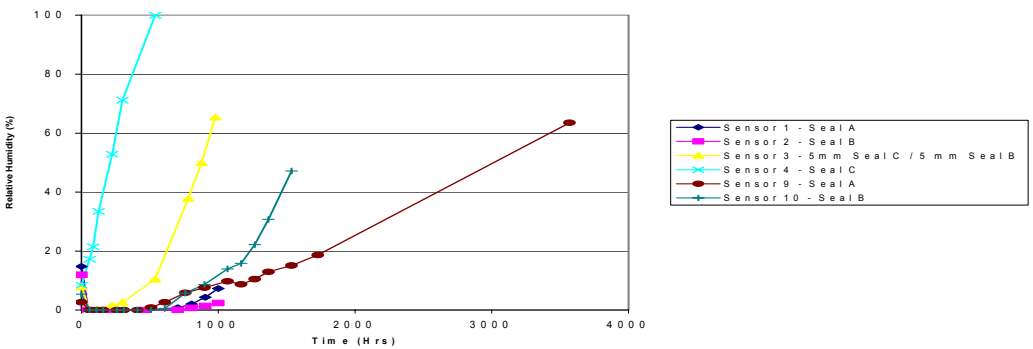


Chart 1: Both Seals A & B contained high levels of desiccant, resulting in very low RH levels within the package after 1000hours. Seal C contained no desiccant, and very quickly became saturated, even if used in combination with another material (as a potential reduced-cost option). Even after >3000hours exposure, RH levels for Seal A only just began to exceed ambient conditions. As these samples were prepared without encapsulant, performance of a more complete solution could be expected to be even better.

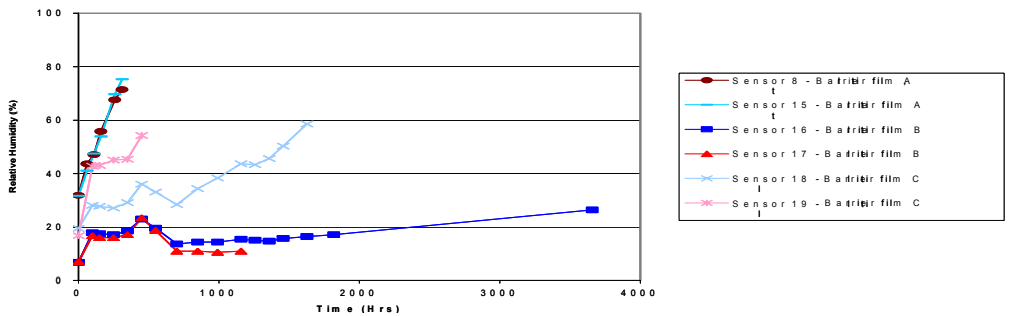


Chart 2: Barrier film Samples A, B & C were prepared with identical encapsulant and seal materials. The samples were chosen as representative of differing price/performance points. After only 1000hours there is a clear distinction between the samples, with Sample B significantly outperforming the others. Even approaching 4000hours (to date), the RH levels were still substantially below ambient.

Conclusions

i) Humidity sensors have been successfully utilised in the screening of encapsulant systems

ii) Quantitative results can be generated without the need to fully appreciate different cell technology characteristics

iii) The approach is being extended to compare material combinations and the influence of process conditions