Acoustic *in-situ* Determination of EVA Features

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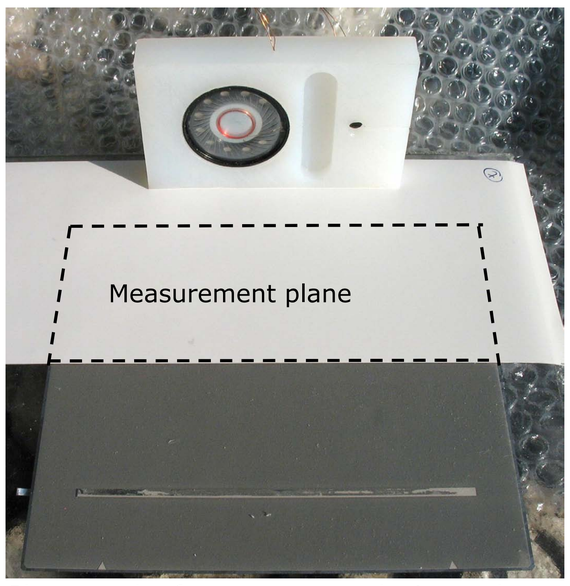
Abstract

The degree of cross-linking of ethylene vinyl acetate (EVA) foils is an important quality criterion for laminated PV cells. A method is proposed that acoustically measures cross-linking in ethylene vinyl acetate (EVA) foils. This technique is both faster and cheaper than existing techniques and, most importantly, it is non-destructive. It has been shown elsewhere that cross-linking is highly correlated with lamination time. We use lamination time as a reference measurement against which we can assess the proposed technique. Seven laboratory samples were tested and the results of the lamination time and the proposed technique were found to be correlated (R^2=0.93). Therefore, we conclude that the proposed technique offers a cheap online alternative to current Soxhlet testing techniques.

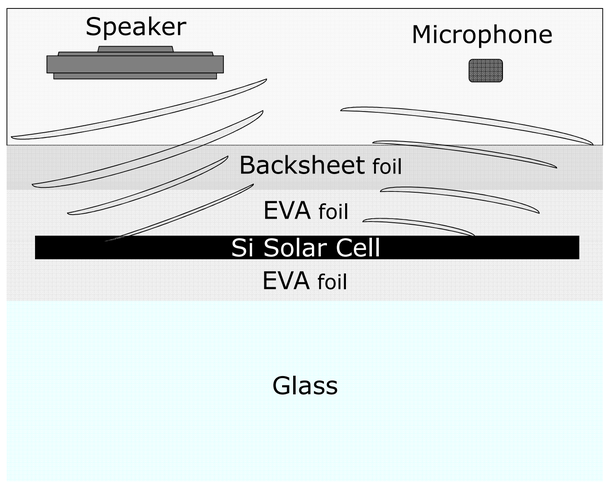
Measurement Setup

A sensor device consisting of a small speaker and a microphone was constructed.



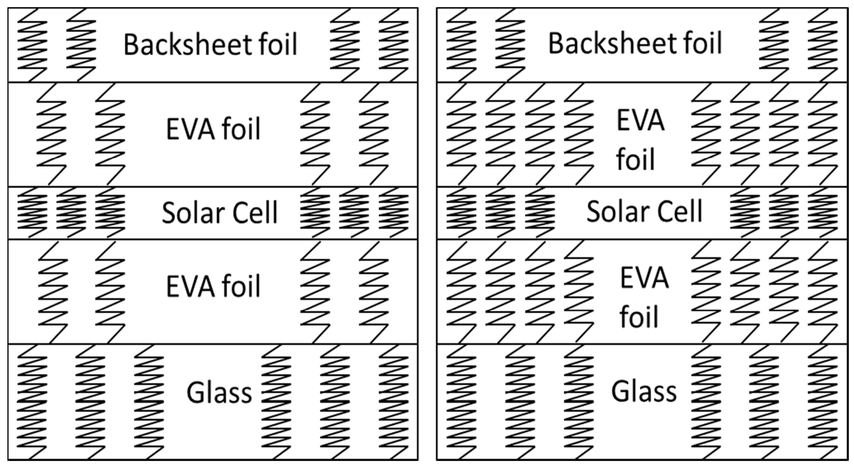
Photograph of measurement device and sample.

Waves transport energy and momentum. When sound propagates through a stiff structure it is attenuated depending on material.



Measurement setup and sample structure.

For a better imagination:
The setup with different lamination samples can be understood as a mechanical spring model. Different laminated EVA foils have a different stiffness.



Spring model "soft" (left) and "hard" (right) EVA foil.

Experimental Procedure & Results

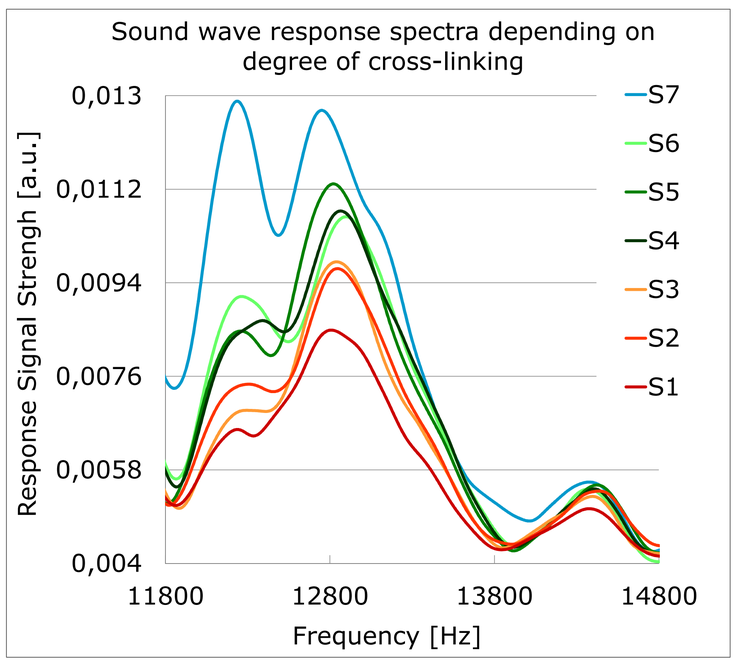
The speaker emits a continous spectrum of sound waves over the range 10Hz to 20 kHz. Each of seven laminated samples was measured 30 times and the average calculated. Two features are extracted from the returned signal in the range 11800 Hz to 14800 Hz:

- Change in total power of the signal
- Shift in resonant frequency

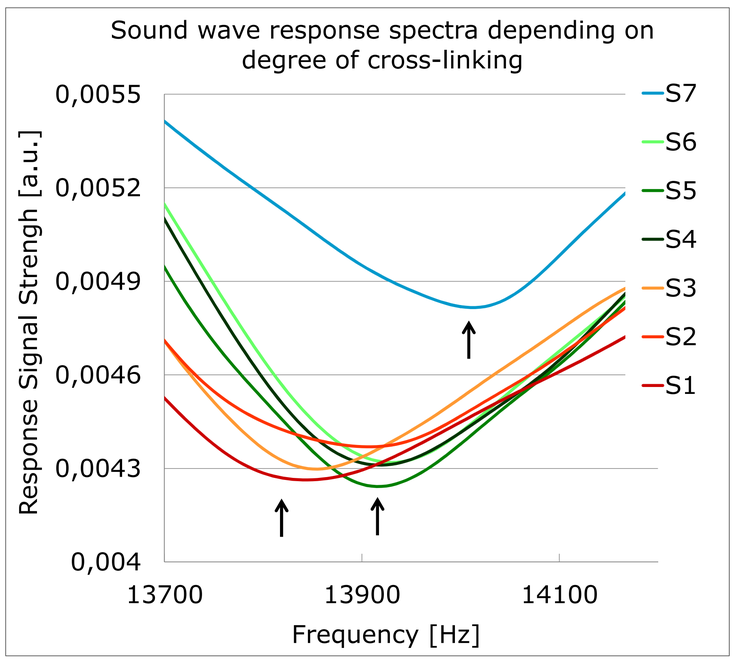
Colour	●	●	●	●	●	●	●
Lamination Sample	S1	S2	S3	S4	S5	S6	S7
Lamination Time [s]	120	300	360	500	560	590	800

Classical Chemical Method (Soxhlet)

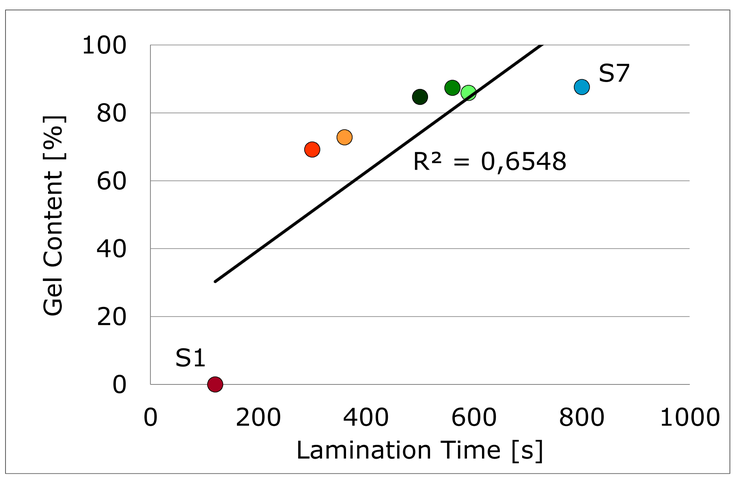
New Acoustic Sound Method



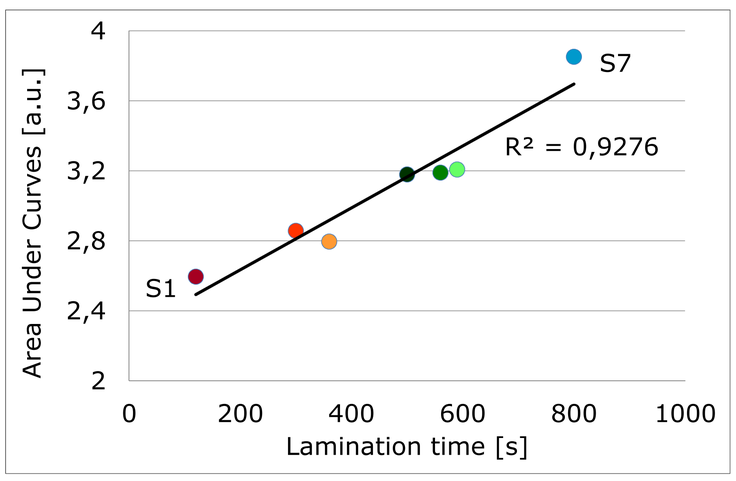
Sound wave spectra of seven different laminated samples.



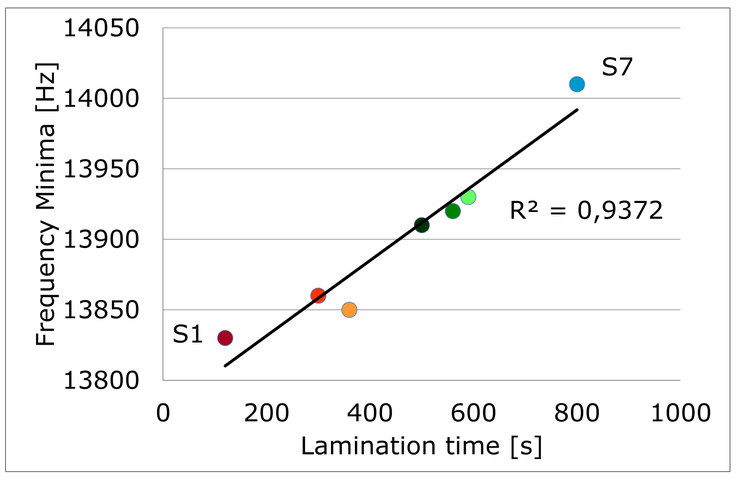
The shift in resonant frequency for different samples.



Relationship between Soxhlet gel content feature and lamination time.



Relationship between the acoustic power feature and lamination time.



Relationship between the acoustic resonance shift and lamination time.

Conclusions

This work presented a novel inspection technique that can measure the degree of crosslinking of EVA sheets in fully assembled PV modules within a few seconds without damaging the samples. Our initial results show that the technique is more accurate than the Soxhlet extraction which is the standard technique used in industry. The proposed technique therefore has considerable potential as an online inspection system.

Acknowledgements

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