# X Link®– in-line testing of EVA cross-linking degree

LayTec has developed a novel in-line metrology system that monitors the quality of the solar module lamination process. The degree of EVA cross-linking can now be tested in a fast, automated and non-destructive manner. In contrast to conventional approaches, the new method allows for closed-loop process control and gapless quality assurance. This way, the impact of intentional and unintentional changes to the lamination process is quickly evaluated.

In solar modules, the ethylene vinyl acetate (EVA) encapsulation protects the sensitive solar cells from the environment. In consequence the degree of intermolecular cross-linking of EVA is decisive for the long-term stability and performance of a module. Cross-linking is achieved by thermally curing the EVA during the lamination process. Until recently, process control and quality assurance had to rely on destructive, lab-based tests for monitoring lamination quality.
In order to meet the demand for in-line testing of the degree of EVA cross-linking, LayTec advanced a metrology concept developed by Fraunhofer USA [1]. As a result, LayTec X Link® provides fast (~10 s), automated and non-destructive determination of the level of EVA cross-linking with a precision of ± 1.5 %.

The testing method is based on the correlation between the level of cross-linking and the EVA's mechanical properties, which are gauged through the backsheet. In addition, the module temperature is measured which has to be between 80°C and 100°C.

From the recorded data the degree of cross-linking is determined and given in form of a figure of merit, the LaTec cross-linking metric (LXM). Here, we present results which were obtained for a series of five modules which were laminated under various conditions.

For each module, four locations were tested. First, the non-destructive X Link® measurement was carried out ten times. Subsequently, EVA samples were taken from the same locations and analyzed by conventional Soxhlet extraction. The results are illustrated in Fig 1.

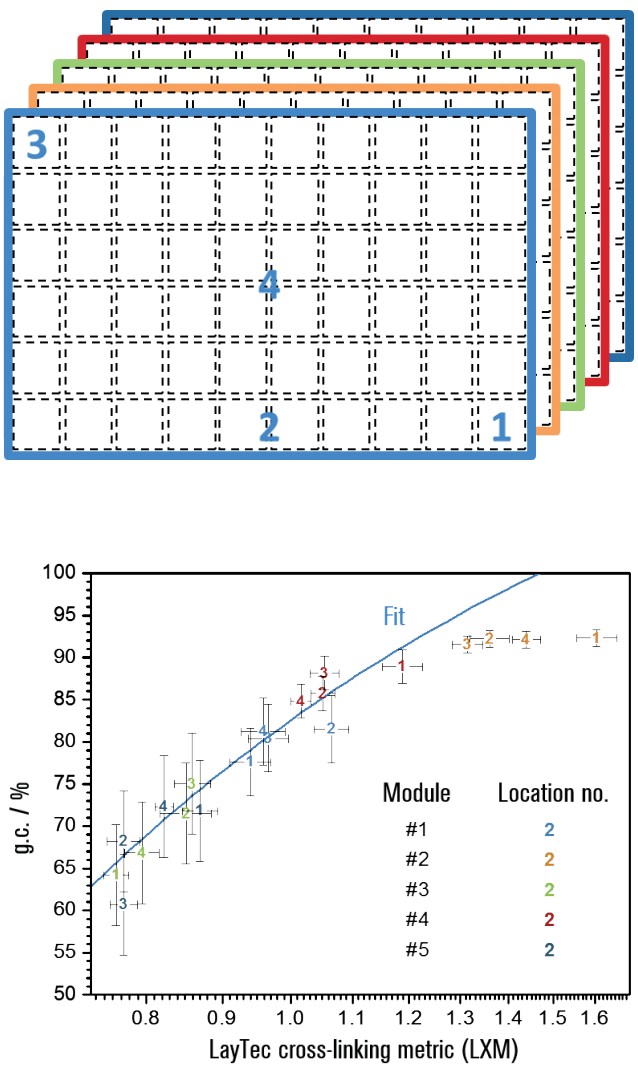


**Fig. 1:** Correlation between LXM and gel-content. Top: Sketch of modules and locations used for comparison. Bottom: Experimental results. Data courtesy of Q-Cells SE.

A clear correlation is found between the two methods, covering the differences between the modules as well as spatial inhomogeneity on individual modules. Consequently, X Link® can substitute for Soxhlet extraction.
A typical phenomenon of Soxhlet extraction is its sensitivity limit for high values of cross-linking (> 93 % gel-content). This can be observed in Fig. 1.
In contrast, X Link® is capable of distinguishing between different cross-linking values even beyond the limit of the Soxhlet extraction. In particular, for low cross-linked EVA, the projection of the error bars onto the fit reveals a superior accuracy of X Link® as compared to Soxhlet extraction.

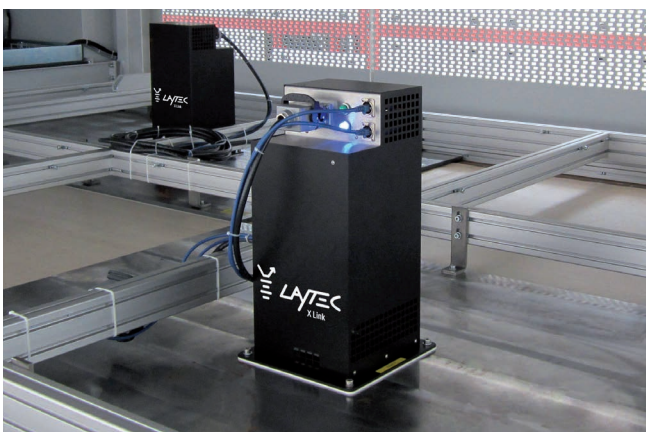


**Fig. 2:** X Link® measurement heads installed on top platen of cooling press of Meyer Burger NG Laminator

The results are plotted in Fig. 3 over the respective LXM values recorded in-line within the cooling press. The clear correlation demonstrates that X Link® offers reliable in-line testing of the EVA cross-linking degree detecting intentional and unintentional changes to the lamination process.

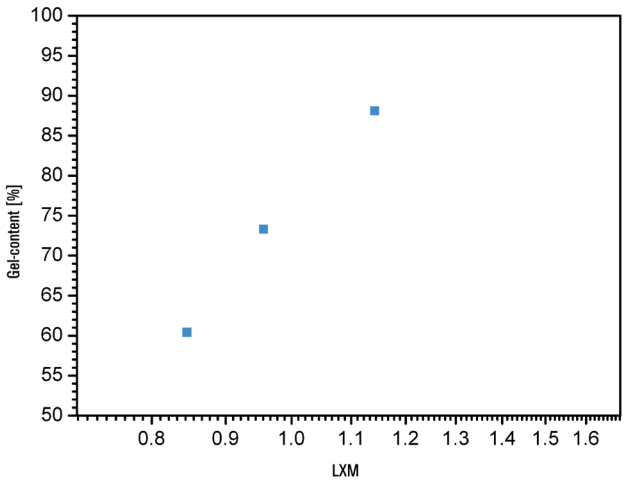


**Fig. 3:** Correlation between the LXM and the gel-content. The former was determined automatically and non-destructively within the production line. The latter was obtained by a lab assistant after destroying the modules and waiting another 48 hours.

For more information please visit www.laytec.de/xlink
or contact info@laytec.de.

[1] B. MacBride, Fraunhofer CSE, "LayTec and CSE Partner to Successfully Commercialize a New PV Metrology Method", www.cleantechnotes.org/2012/06/laytec-and-cse-partner-to-successfully-commercialize-a-new-pv-metrology-method, accessed February 2013
[2] D. Rieder, A. Maiocchi, Meyer Burger AG, Devision Module, "In-line integration of testing EVA cross-linking degree", abstract submitted to EUPVSEC 2013



LayTec AG
Seesener Str. 10-13
10709 Berlin, Germany

Tel.: +49 (0)30 89 00 55-0
Email: info@laytec.de
Web: laytec.de