PRINTED ULTRATHIN PAPER SENSORS – THE FRUGAL WAY TO STUDY THE ONLINE CROSSLINKING OF RESINS AND GLUES

Uwe Müller[a], Martin Kaltenbruner[b], Arunjunai raj Mahendran[a], Rainer Nachbauer[c], Franz Padinger[d], Melanie Steiner[a], Thomas Stockinger[b]

[a] Kompetenzzentrum Holz GmbH (Wood K plus), Altenbergerstraße 69, 4040 Linz, AT
[b] Soft Matter Physics, Johannes Kepler University, Altenbergerstraße 69, 4040 Linz, AT
[c] Kästle GmbH, Kaiser-Franz-Josef-Strasse 61, 6845 Hohenems, AT
[d] SCIO Holding, Franzosenhausweg 51, 4030 Linz, AT

The printing press with movable types invented by Johannes Gutenberg in the 15th century plays a key role in the development of the scientific revolution in the Renaissance, and laid the material basis for the modern knowledge-based economy as well as the spread of learning to the masses [1]. Around 600 years later, advanced printing methods were used to create thin electronic devices by printing on a variety of flexible substrates and even on paper in order to integrate functionality directly on various materials. This allows the integration of sensors in any object, size or material [2].

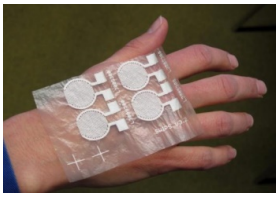
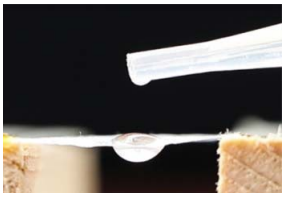
a)

b)

c)

Fig. 1: Sensor in skis (a), printed sensor on ultrathin paper (b), demonstration of high porosity (c)

Printed sensors on ultra-thin paper allow undisturbed observation of resin flow and crosslinking in complex components like engineered wood, skis, luge or wings by using impedance spectroscopy. Sensors printed on highly porous materials have hardly any influence on the properties of the composite materials, regardless of whether they are made of wood, carbon or glass-fibre. The matrix resins penetrate through these sensors within a few seconds. Sensors on highly porous, ultra-thin paper can be completely integrated into complex shapes without impairing the properties of the composite materials.

Our results show that printing is possible almost on all papers, but not every paper is suitable for impedance spectroscopy, because many paper additives influence the crosslinking kinetics. However, simultaneous measurements with other methods (ir, DMA, mechanics) show that high-resistance papers do not falsify the measurement. Applications of printed sensors in engineered wood, carbon (skis) and glass composites (luge) are presented in the paper. Strengths but also weaknesses are discussed.

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[1] E. Eisenstein, “The printing Press as an Agent of Change”, Cambridge University Press, ISBN 0-521-29955-1 (1980).

[2] www.quad-ind.com/printed-electronics; downloaded February 28, 2019.