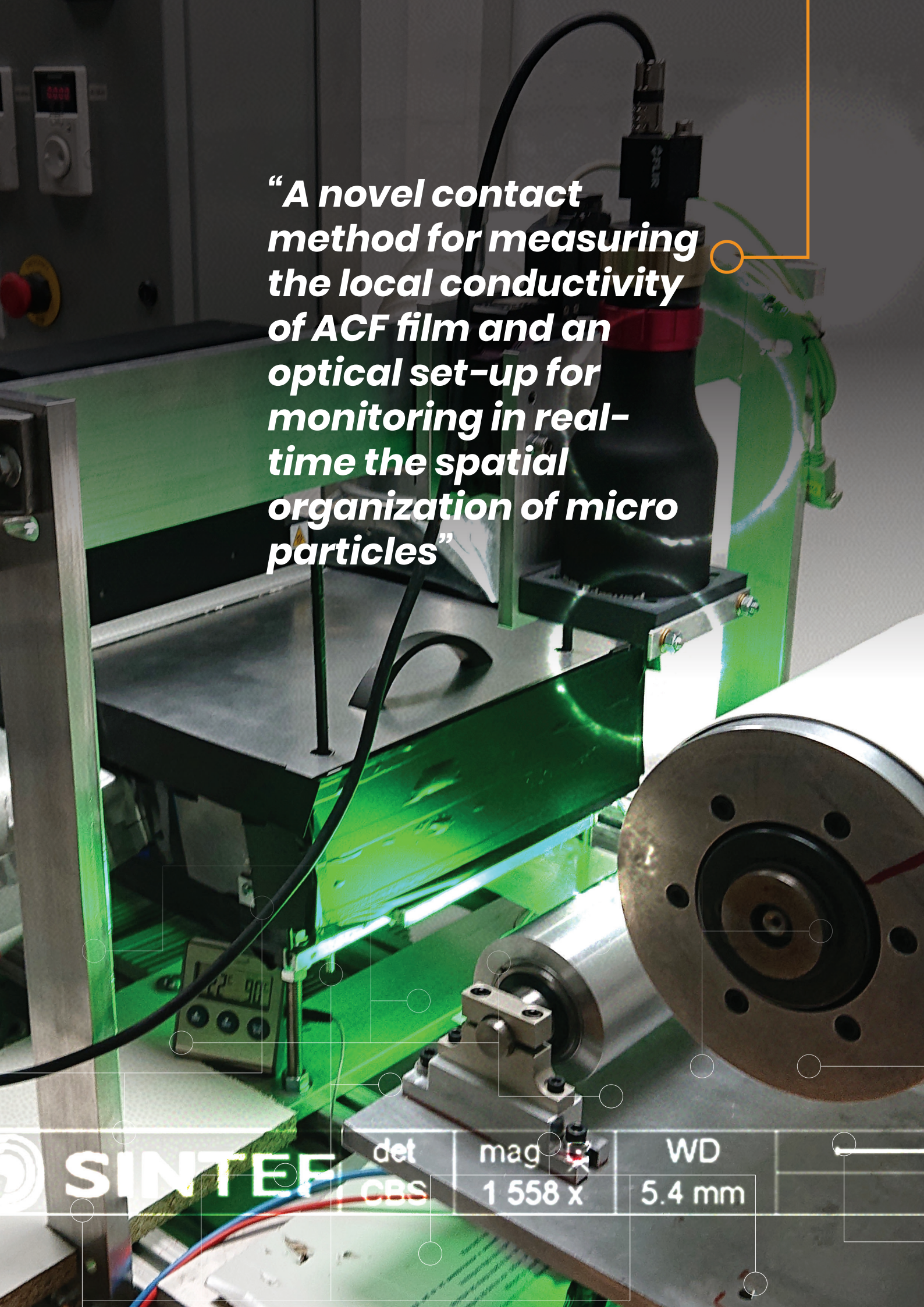


"A novel contact method for measuring the local conductivity of ACF film and an optical set-up for monitoring in real-time the spatial organization of micro particles"

AniConFilm

Manufacturing technology of nano-structured anisotropic conductive films

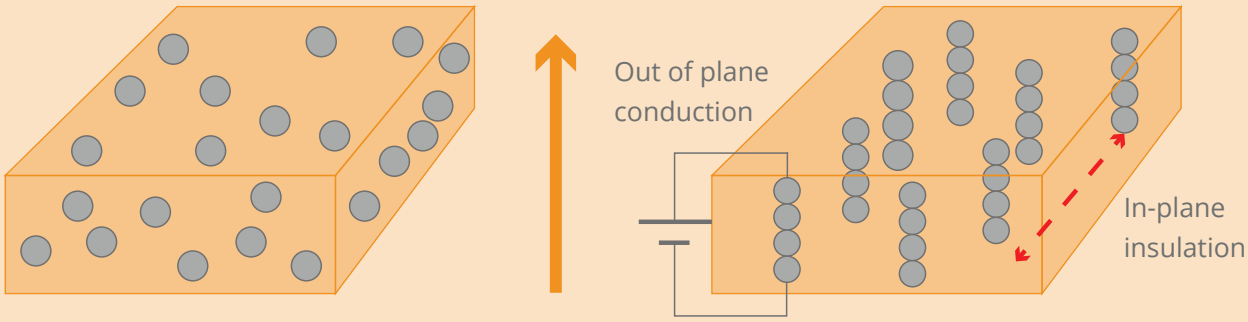
In the Manunet project AniConFilm, the project partners CondAlign AS (Norway), SINTEF Digital (Norway), Technical University of Iasi (Romania), and SC ALL GREEN SRL (Romania) worked together to improve an innovative manufacturing process for continuous roll to roll production of nanostructured anisotropic conductive films (ACF), based on CondAlign's alignment technology. ACFs are film-type conductive adhesives allowing electrical and mechanical connection. They are used in applications like display production, printable flexible electronics and thermal interface materials. Gregory Bouquet, research scientist at SINTEF, a contract-based research institute in Norway: "The innovative manufacturing process of CondAlign is able to achieve significant cost reductions compared to competing technologies in the field of anisotropic conductive films. In addition, the optical set-up developed in the project enables CondAlign to monitor the quality of the fabrication process in real-time. During the innovation project not only the application areas of the technology have been expanded expanded, but also research has been done into market-oriented applications in end products."

Tailor-made chain architecture

"The project actually consisted of two sub-developments," says Bouquet. "For example, SINTEF Digital, the organisation to which I am affiliated, concentrated on the development of measurement tools to characterize, understand better and help in optimizing the fabrication process of CondAlign. We developed a novel contact method for measuring the local conductivity of ACF film and an optical set-up for monitoring in real-time the spatial organization of micro particles in continuous roll to roll production. These are very important tools to guarantee the quality of the anisotropic conductive films during the manufacturing process. Our Norwegian Partner, CondAlign AS, has focused on furthering the development of their process that uses electric fields to align and distribute particles in polymer films. This allows production of ACFs with added functionality and reduced cost compared to other technologies. They have in the project worked with both electrically and thermally conductive films. A major challenge has been to understand the effect of the particle size, film thickness and electric field parameters have on the end properties, such as electrical conductivity. A design of experiment approach, performed together with SINTEF, was instrumental in furthering this understanding."

Manufacturing process for anisotropic conductive films

The manufacturing process for anisotropic conductive films is very complex. In the technology patented by CondAlign, the films are initially made by mixing a specific set of micro-particles with a polymer. It is important to understand what kind of polymer must be used and what kind of particles are optimal for meeting the requirement for the specific product in question. "We have done extensive work on this in a separate work package," says Henrik Hemmen, CTO of CondAlign. The liquid mixture of polymer and particles is then applied to a liner before it is pressed between a pair of rollers to the desired thickness and width. After that, the films are subjected to



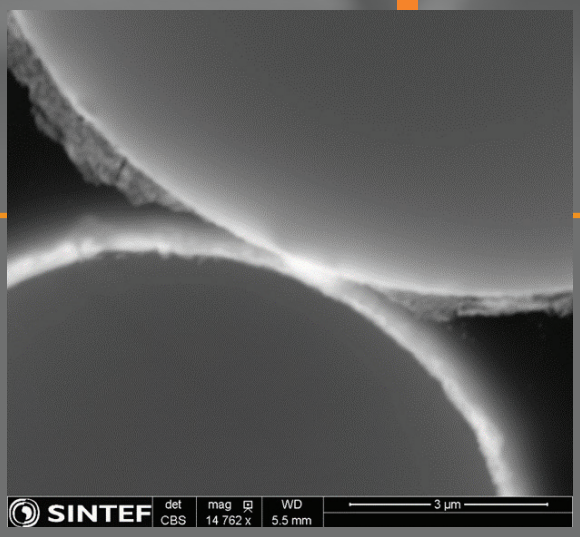
Conductive particles are mixed into a liquid polymer matrix

An Electric field applied tot the mixture causes the particles to align into chains

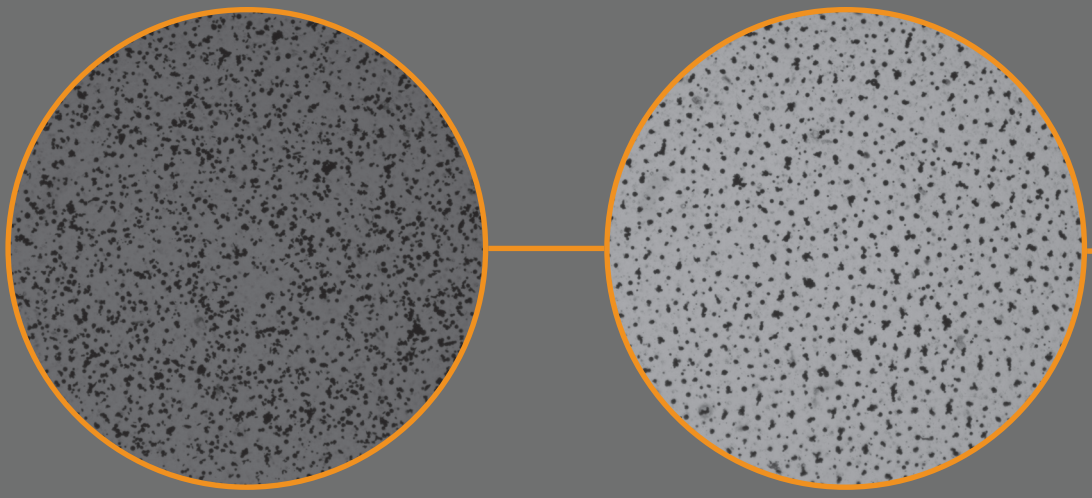
The particles distribution allow current to flow through the plane but prevent conduction in the plane

Fabrication process of the CondAlign´s ACF: Conductive particles aligned in chains allow conduction of current and/or heat in the out-of-plane direction and are insulating in the in-plane direction

Tailor-made chain architecture



SEM images of the cross section of an ACF film showing a conductive chain and physical contact between aligned particles



Spatial organization of particles before (left picture) and after (right picture) alignment as observed in microscopy

an electric field by a set of electrodes to align the particles into chains. These chains are then locked in position by curing the polymer with UV light. Finally, the imaging system developed by SINTEF analyses the films to determine if they meet the required quality standards. "The system developed in this project has allowed us to speed up our manufacturing and quality control," says Hemmen. "We no longer need to remove parts of the film and in some cases wait several days to determine product quality. Our quality control can now be done in real-time. This opens doors to new electronical and biomedical applications and products."

Applications in Printable Flexible Electronics and Health Care

Anisotropic conductive films are developed for a wide range of industries. These include not only printable flexible electronics, where films developed in the project can be used in displays and smartphones, but also the medical industry, where ECG electrodes are used to monitor heart health. The challenge with the latter is that these have to be produced in such a way that they stay on the body easily. However, the largest market remains that of printable flexible electronics. There is currently a transition here from glass substrates and rigid plastic to more bendable materials. The flexible films that can be produced with help of the quality control system developed in the innovation project, could be part of the solution to enable curved and flexible products.

Imaging system for micro-level quality inspection

Bouquet: "An important technical challenge during the project was that the particles we wanted to monitor with the imaging system were very small, approximately 10-30 micrometres, while the film width is several orders of magnitude larger, approximately 7 cm. Moreover, while the conductive films are being manufactured, these micro particles are constantly moving. If you want to have a good insight into whether the particles are aligned correctly, you need an imaging system that can also freeze their movements. The imaging system we have developed can therefore be compared to an industrial microscope that can inspect large areas with high optical resolution. The development of an image analysis algorithm was essential to quantify the quality of the manufacturing process. The micro particles in the films organize themselves into very specific spatial structures, which can be detected using the optical system combined with the image analysis algorithm. It was very challenging that this process had to take place in real-time."

Close-to-market activities

The added value of Manunet was obvious. "It is a very effective instrument that is close-to-market and helps innovative companies carry out research and development projects. The Manunet framework was therefore perfect for us to solve the various technical challenges on a project basis. The prototype of the imaging system has now been installed at our partner CondAlign AS and they are using it in their product development. The project has resulted in an important process improvement which will contribute to better meet the high requirements from the large number of customer interested in these advanced materials. Now CondAlign AS is in a process to implement an even larger manufacturing process, in which films up to 32cm wide will be produced. For this it is important to monitor the production process in real-time. The optical set developed in the project will of course be used here again."

Effective cross-border cooperation

"During the innovation project we worked together with the Romanian partners, University of Iasi and the company SC ALL GREEN SRL. This collaboration was very effective and there was a clear division of tasks. There were also regular project meetings with our partners and we visited each other several times. The Romanian partners focused on carrying out specific measurements using advanced characterisation tools such as scanning electron microscope (SEM). Characterisation of physical properties at the nanometre level was important to better understand and further optimise the manufacturing process. Moreover, our Romanian partners carried out simulations of the behaviour of particles in the ACF under various electromagnetic field."

Gregory Bouquet

Acronym
AniConFilm

Call
Call 2017

Coordinating Funding Agency
RCN

Participating partners
SINTEF Digital (Norway)
Technical University of Iasi (Romania)
CondAlign AS (Norway)
SC ALL GREEN SRL (Romania)

Project duration
24 months

Total project cost
€ 850.000

Henrik Hemmen
CTO CondAlign

Contact
SINTEF Digital
Gregory Bouquet
(47)98230482
gregory.bouquet@sintef.no
https://www.sintef.no

"Manunet supports innovation-driven, close-to-market research and development projects in manufacturing. It aims to encourage cross-border value chains that emerge from advancing technologies"

Manunet project consortium