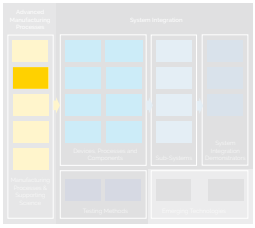

FLAGSHIP

ADVANCED MANUFACTURING PROCESSES

Advanced rheology for printing large-area electronics (ARPLAE)

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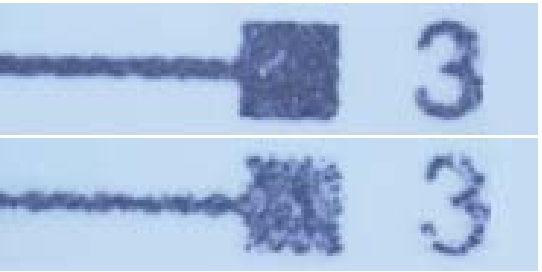
The ARPLAE project addresses fundamental rheological challenges to achieving high-resolution features in the production of functional inks in high-yield contact printing processes. Typically, the ink systems used in these processes display complex rheology (deformation and flow properties) which can complicate the characterisation of the materials and hinder attempts to predict process performance. Improved understanding of the rheological aspects of these processes and materials is required to establish a rigorous basis for their better prediction and control.

Key achievements

- Rigorous validation of controlled stress parallel superposition rheometry.
- Demonstration of the utility of superposition rheometry in providing data of both process and material relevance to the printed electronics industry.
- Rheological characterisation and print trials on a number of model functional ink formulations.



Lines printed using identical print process with inks that are indistinguishable under quiescent conditions. Under CSPS conditions the distinct rheological characteristics of the materials become apparent.

Project objectives

- A radically improved understanding of functional ink formulation and its interaction with the image carrier and substrate to optimise performance for high resolution printing;
- The development of scientifically rigorous techniques for characterisation of the critical rheological properties of fluids in high deformation rate shear and extensional flows in order to achieve optimal performance; and
- The establishment of performance metric(s) based on the first two objectives.

Methods of fluid characterisation capable of replicating industrially relevant rates of deformation, deformation amplitudes and timescales are largely inaccessible to industry and our study has demonstrated that the rheometrical techniques employed by many lack process and material relevance. The ARPLAE project is developing advanced rheological techniques and characterisation processes which have been employed successfully in other areas e.g. in rheological aspects of high speed machine lubrication. These techniques are presently focussing on the exploitation of superposition flow rheometry in which small amplitude oscillatory flows are used to probe fluid microstructural responses to imposed, process-relevant large amplitude shear flows hence providing information possessing both process and material relevance.

By measuring the rheology of a range of functional inks using state-of-the-art characterisation tools and by understanding the effect of rheology on physical processes such as cavitation that occur during printing, the data for a predictive model is being obtained to enable ink rheology to be optimised for improved quality and yield in printing. The project seeks to define a measure of functional ink characteristics which can be incorporated in the development of better performing fluids, and in improved methods of predicting the consequences of changes in ink formulation.

The initial phase of the ARPLAE project involved a scoping study which identified target functional inks and print processes where performance improvements will have highly significant commercially benefits. The project has a special focus on gravure printing due to its suitability for the production of quality-sensitive layers like organic semiconductors and semiconductor/dielectric-interfaces in transistors. The initial phase of the project has demonstrated that the new rheometry being developed under ARPLAE provides a successful new basis for predicting the outcomes of an industrial print process in terms of a product performance metric – with significantly improved outcome over established techniques in terms of relating changes in product formulation to product functional performance. The current phase of ARPLAE is building on these exciting findings with a range industrial partners and model formulations based on silver, carbon and zinc oxide functional components. Further rheometric advances are being explored that optimise the information content of the tests.