



Cluster R

Roll-to-Roll Processing

Center for UMass-
Industry Research in
Polymers (CUMIRP)

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A pre-commercial research consortium exploring the science of nanostructured flexible device manufacturing on large-format roll-to-roll platforms

Joining UMass Amherst's **Cluster R** industry consortium for roll-to-roll processing research is an efficient way to leverage innovation in advanced coating and printed electronics at a national nanotechnology research center. We focus on the fabrication and characterization of polymer-based nanostructured materials, hybrid nanomaterials and templates on scaled, flexible substrates via roll-to-roll (R2R) process platforms.

Cluster R research expertise includes synthesis of polymer and polymer-nanoparticle systems, self-assembly of complex nanostructures, process modeling, control, and characterization for high-throughput, flexible substrate processing platforms. Methods studied within this cluster include roll-to-roll UV-assisted nanoimprint lithography to prepare substrate patterns with features on the order of 100 nm and below, nanotextured substrates, and continuous patterning of device level features on a web. The cluster also takes advantage of additive-driven self-assembly to prepare well-ordered hybrid materials in which polymer templates guide the assembly of nanoparticles, nanotubes, fullerenes and other materials to produce functional device layers that can be applied via R2R coating techniques.

Combining top-down and bottom-up nanomanufacturing approaches on high-volume R2R enables synthesis and fabrication of complex nanostructured materials and devices over large areas at low cost.

Potential applications enabled by this technology include magnetic metamaterials, membranes (separations or selective transport), magnetic storage, sensors, displays, energy (harvesting and storage), barrier films, and flexible electronics.

Cluster R is the industry affiliate program of the **Center for Hierarchical Manufacturing (CHM)**, an NSF Nanoscale Science and Engineering Center at the University of Massachusetts Amherst specializing in nanomanufacturing. The CHM supports a roll-to-roll processing facility that includes R2R nanoimprint lithography and hybrid materials coating tools. CHM research includes demonstration projects on photovoltaic devices and flexible batteries. Cluster R leverages research contributions in the CHM from several disciplines, including Polymer Science and Engineering, Mechanical Engineering, Chemistry, Chemical Engineering, and Physics, investigating the transition of self-assembly processes adapted to scaled flexible substrates.

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Center for UMass-Industry Research in Polymers (CUMIRP) Scope of Current and Future Projects

Planarization. The development of cost-effective and robust planarization layers is essential for many applications. This project involves the use of in-line planarization to achieve 1 nm RMS surfaces as a low-cost alternative to pre-planarized films. The approach can be adapted for introducing functionality into the layer.

Imprint Embossing and Patterning. The goal of Cluster R imprinting research is to develop conditions to enable a wide variety of continuous process fabrication methods. Critical dimension sizes of imprinted features may vary widely depending upon the application but optimized to 50 nm for arbitrary patterns and 1-5 nm for large area nano-texturing for self-assembly. While production speeds of 25 M/min are attainable, speeds up to 1 M/min are envisioned for nanopattern transfer. Other parameters being studied and optimized include patterns aspect ratio (> 10:1), minimization of residual layer (< 5 nm), wet and dry etch, adhesion to substrate and release from mold, and substrate variation (PET, PEN, Polyimide, paper).

Alternative Conducting Layers. There is a clear and immediate need for alternative conducting films for device applications especially in the area of transparent conductors. Work in this area explores development of polymer/nanoparticle and polymer/additive systems to achieve coatable films with excellent conductivity.

Nanoporous Membranes. Many applications require nanometer-scale porosity on a supported or unsupported film. Cluster R nanoporous membrane research explores the use of block copolymer additive systems in which the additive undergoes phase selective chemistry or is used as a porogen that can be selectively removed to generate robust films with well-defined pores.

Functional Hybrid Films. Many applications require thin polymer films whose behavior is defined by additive packages. Research in this area explores the design and development of polymer/additive films with high loadings of a functional component such as a nanoparticle. Targets include high refractive index films, polymer-based films with high or low dielectric strength and semiconducting films with improved carrier mobility.

Coating of Viscoelastic Fluids. Many applications will require the production of films from coating fluid containing polymer and/or nanoparticle additives. The resulting fluids can become rheologically complex. Studies explore the effect that viscoelasticity has on gravure and slot coating systems so that they can be optimized for use with a wide spectrum of coating fluids.

R2R Integration Issues. This topic covers challenges for device integration on the web, with potential projects including selective area metallization by lift-off or etching through a NIL mask.

Design for Manufacturability. To lower development time and cost in R2R production of multifunctional devices, research focuses on design-process prototyping to establish design rules for simple devices that utilize heterogeneous nanostructured materials to combine electronic, magnetic and optical properties on a continuous line. Low-cost signal manipulation, sensing, power management, and communication are key issues.

CUMIRP Consortium Membership Costs

Annual membership dues are based on company size as determined by annual sales and number of clusters selected.

Company Size by Annual Sales	1 Cluster	2 Clusters	3-4 Clusters
Large Company: \$1 billion and over	\$30,000	\$48,000	\$ 60,000
Medium Company: \$100 million to \$1 billion	\$18,000	\$28,800	\$ 36,000
Small Company \$100 million and under	\$6,000	\$9,600	\$ 12,000

Massachusetts companies joining **Cluster R: Roll-to-Roll Processing** are eligible for a 50% cost reduction for the first year of membership. Companies already participating in the CUMIRP program (Parts II, III and IV) may be eligible for additional discounts in the CUMIRP Part I program. Contact the CUMIRP Office to obtain a sample membership agreement.

CUMIRP Structure

Part I: Research Consortium (NSF I/UCRC Format) comprised of "Clusters" of related research topics:

- Research Cluster B: Polymers in the BioArena
- Research Cluster E: Polymers in Energy
- Research Cluster F: Fire-Safe Polymers and Polymer Composites
- Research Cluster M: Mechanics of Polymers and Composites
- Research Cluster N: Nanostructured Materials

Research Cluster R: Roll-to-Roll Processing

- Part II: One-on-One Sponsored Research
- Part III: Unrestricted Research Grants
- Part IV: Short-Duration, Idea-Development Research Projects

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