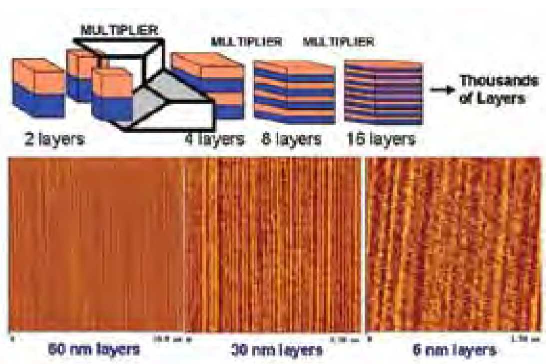
CENTER FOR LAYERED POLYMERIC SYSTEMS CLiPS

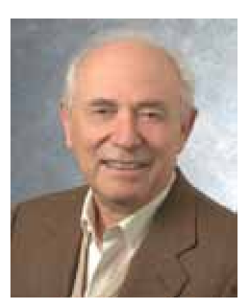
MAKING MULTILAYERED MATERIALS WITH NOVEL PROPERTIES

MANY LAYERS MEAN MANY POSSIBILITIES. THAT'S THE CENTRAL IDEA OF THE ENABLING TECHNOLOGY BEHIND THE CENTER FOR LAYERED POLYMERIC SYSTEMS (CLIPS), HEADQUARTERED AT CASE WESTERN RESERVE UNIVERSITY.



CLiPS researchers are working at the intersection of polymer science, engineering, chemistry, physics, and biology to catalyze the development of nanolayered materials and to facilitate their transfer to the commercial sector through partnerships with industry and other organizations.

Serving as center director is Eric Baer, who holds the title of Distinguished University Professor, and is the Herbert Henry Dow Professor of Science and Engineering in the department of macromolecular science and engineering at Case Western Reserve University.



Eric Baer

The center is using a unique enabling process that takes two polymer melts and combines them as two layers, multiplies the layers to four, and doubles that again as many times as desired. Soon you have thousands of layers of alternating polymers, and these layers can be as thin as 50 angstroms. When polymers are combined in this so-called "forced assembly," magical things can happen. The multilayered material can behave quite differently than the starting ingredients. What was once brittle becomes ductile in a multilayer. Colorless ingredients now give off a color without the presence of dyes.

As layers become thinner and thinner, the effect of the interface between these materials begins to dominate, says center investigator Donald Paul, professor of chemical engineering at the University of Texas at Austin and director of the Texas Materials Institute. "What happens is not so well understood," he admits. "Therein lies the frontier."

CLiPS researchers have developed tunable multilayer polymer lasers, one using stretchable elastomeric polymers and one using previously developed laser sheets. Both of the lasers demonstrate how simply folding the pliable polymer sheets can create lasers whose emission color can be tuned.

"Generally lasers are not so easily tunable or so inexpensive. Because these lasers possess those attributes, they have potential applications in remote

Graduate students Matthew Mackey and Jessica Patz

sensing, medicine, communications, and displays," says Ken Singer, a CLiPS project leader and associate director for external affairs.

In the case of elastomeric lasers, folding the structure places a thick dye-infiltrated skin layer between multilayer polymer reflective structures. As the laser is stretched, the output color can be tuned over a 50 nanometer range.

Another thrust deals with barriers and membrane systems that have applications, for example, in the food industry. Keeping vegetables fresh requires that the packaging material allow the right exchange of gases in and out of the package. Because each vegetable has unique needs in terms of gas transport, researchers are exploring the possibility of tailoring the performance of multilayered materials to extend shelf life of produce and perhaps even control the timing of ripening of packaged fruit.

Currently, gas separation membranes are produced by methods that rely on the use of large quantities of environmentally undesirable solvents. But CLiPS' multilayer coextrusion method can entirely remove solvents from the production process. "This is a good example of a value-add application of the multilayering process," says Baer. "The films produced are not only better and safer for the environment, they open up new horizons for their use." □

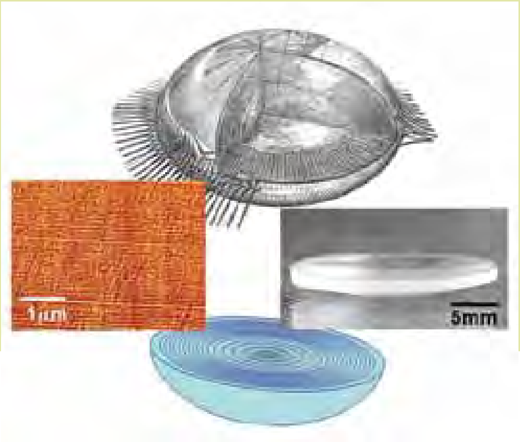
KNOWLEDGE TRANSFER

LAYERED LENS TECHNOLOGY FOR ADVANCED CAMERAS

Researchers at the center have taken inspiration from nature in the development of nanolayered lenses that are not unlike the lenses in the eyes of fish.

In fish lenses, the material's ability to bend light, or refractive index, gradually changes with depth inside the lens: in other words, they have a refractive index gradient. "We are able to copy that using the nanolayer approach," says center research chair Eric Baer.

Lenses of this type exhibit a wider field of view with less aberration than conventional lenses having no index gradients. The "gradient refractive index" or GRIN lens shown in the figure below mimics a segment of the octopus lens. It contains more than 500,000 nanolayers.



Gradient Refractive Index (GRIN) Lens

Polymer Envoy Santiago Chabrier and his graduate student mentor, Guojun Zhang

NEWS WATCH

FOCUS ON STARTUP COMPANIES

Research from the Center for Layered Polymeric Systems (CLiPS) has led to the establishment of two new science and materials-based start-up companies.

PolymerPlus LLC, founded in 2010 out of Case Western Reserve University, is a Cleveland, Ohio based start-up which has incorporated a CLiPS multilayer polymer processing technique to produce films with hundreds or thousands of layers. PolymerPlus is developing manufacturing facilities and an infrastructure to transform these nanolayered polymer films into gradient refractive index polymer lenses for strategic lightweight imaging and energy collection devices. Stemming from unique interactions of light with the polymer nanolayers, these new lenses may be able to combine the optical power of a series of glass or plastic lens components into a single lens. Utilizing a forced-assembly process to coextrude nanolayered polymer films, PolymerPlus aims to manufacture a new class of polymer lenses with improved optical performance and reduced weight leading to miniaturized optical systems and more effective solar cell devices.

Advanced Hydro, founded in 2008 out of the University of Texas, Austin, is utilizing a membrane coating based on the attachment of mussels to ship hulls. The approach has achieved improvements in water filtration performance and reduced fouling, thereby extending the life of commercial water filtration membranes. Advanced Hydro aims to extend the lifetime and reduce the overall cost to operate membrane-based water filtration systems.

PRE-COLLEGE EDUCATIONAL INITIATIVES

The Polymer Envoys Program is the keystone of CLiPS pre-college educational initiatives, providing significant hands-on research experience and mentoring to a select group of high school students from urban school districts, primarily the Cleveland Metropolitan School District.

The Polymer Envoys program matches a high school student with a graduate student in a longitudinal relationship that lasts two or three years and encompasses a six-week session every summer and weekly participation during the school year.

While hands-on research is the principal focus and activity of the program, the Polymer Envoys' experience is enriched by workshop sessions that focus on topics such as the physical and chemical properties of polymers, math skills, guidance and practice with oral presentations, and tips for navigating the college application process, among others.

Polymer Envoys employ their new presentation skills through outreach activities that engage a large number of pre-college students, especially those from underrepresented groups. These efforts help in the recruitment of new students to the program.

Based on the success of the program it has been expanded to all CLiPS partner institutions. "We are very proud of our Polymer Envoys," says Pamela Glover, CLiPS executive director for education and planning. "Twenty students have graduated from the program to date – and all of them are in college. Sixteen of them are studying in STEM fields. This record of success far exceeds the college admissions rate of the resource-challenged, primarily inner-city high schools that these students attend."

Glover is joined in managing CLiPS education programs by Tryreno Sowell and Pamela Cook, directors for education and diversity at CWRU and at the University of Texas, respectively. David Schiraldi, CLiPS associate director for education & diversity, provides technical leadership to the Center's educational vision and programming.

David Schiraldi

Pamela Glover

FACULTY VIEWPOINT

Kenneth Singer & Donald Paul

Q: How do you like participating in the center?

Singer: You have all these people working together, doing things I can't even imagine doing alone... So it really is a team. We have very frequent meetings, pretty much every week, between the faculty and students. We're trying to get the students to collaborate with each other.

Whenever you have a large group working on something, there's a lot of overhead in communication. You meet more, but the payoff is you have many hands helping with the work—you just have to coordinate all the hands.

The laser is a great example of why the team mode is needed. I brought the idea of doing this to the group. Eric and Anne had been working on the process for many years without knowing what the possibilities for lasers were. Then Chris Weder made the dye that goes into the laser to make it work, and he had a key idea on how to get a result quickly. It's not just individual expertise—there's a real synergy there.

It's a creative force; a forcing function that helps people to be better or more creative than they were. What team science does is to take you beyond the cutting edge—when you get together with somebody has an idea that you haven't thought about before, it increases the creativity.

By yourself, you can only be so creative; you can't imagine things you haven't thought about. Everybody improves upon each others' ideas, and there's a certain element of competitiveness—a good kind.

Everybody brings their little corner of science and you end up with a big room.

Q: Why a center?

Paul: Case Western Reserve University has the capability of making laminated thin layer systems. We don't have that at the University of Texas at Austin (UTA) but we have measurement and theoretical expertise that complements expertise at Case.

This is research that would not have happened individually just because of the different skill sets and capabilities that are involved.

I think the students are really excited about the center because it offers a rather different kind of project than just a normal Ph.D. student would pursue. They really do have to interact with these other people, and we envision that UTA students will probably have to go to Cleveland and interact with people at Case, and that's an enriching experience that normally doesn't happen.

To make progress in science and technology, we really need both modes of operation—team and individual. We need an appropriate balance. There are some ideas that happen by only one mode or the other...

You can't be interdisciplinary until you're disciplinary. You have to learn your area first before you have anything to offer to interdisciplinary efforts.

Top: Donald Paul
Kenneth Singer

James Aldridge

Graduate student Ricardo Andrade with students

EDUCATION AND DIVERSITY

CLiPS diversity efforts are integrated in all areas of the Center, from the hiring of faculty and staff through the recruiting of graduate and undergraduate students.

One focus is the summer REU program, which attracts students from across the country to participate in CLiPS research at CWRU. These students work for ten weeks during the summer, often returning in succeeding years. "We have found that CLiPS REU student alumni can be good candidates for the Center's Ph.D. programs," says Pamela Glover, CLiPS executive director for education and planning.

Another focus is the interaction with CLiPS Affiliate Schools. These institutions have high academic standards but do not offer doctoral degrees in CLiPS fields. The Affiliate schools participate in collaborative research and educational activities with the center. This Affiliate pipeline is also a source of graduate school candidates for CLiPS. One such example is James Aldridge, who is in the Ph.D. program in Macromolecular Science and Engineering at CWRU. James engaged in CLiPS research when he was an undergraduate at affiliate Youngstown State University, and is an alumnus of the REU program.