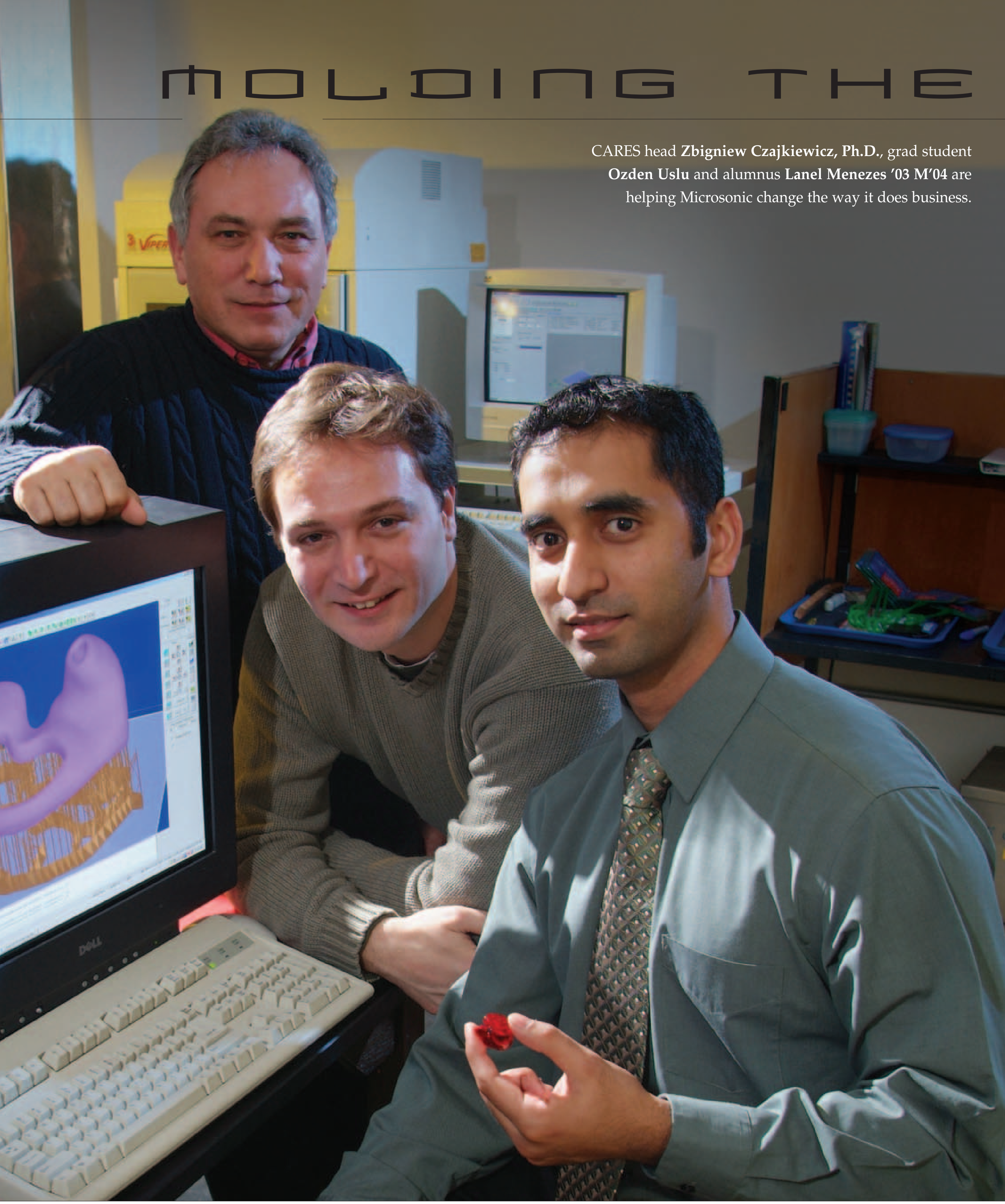
MOLDING THE



CARES head **Zbigniew Czajkiewicz, Ph.D.**, grad student **Ozden Uslu** and alumnus **Lanel Menezes '03 M'04** are helping Microsonic change the way it does business.

FUTURE

Even on a slow day, the shop floor in the Microsonic laboratory is a busy place. The company, which is based in Ambridge, Pa., about 15 minutes from Robert Morris University, is one of the country's leading manufacturers of custom ear molds.

Technicians are at work in most of the plant's dozen or so work stations, and the grinding and polishing machines emit a steady drone. At one station, a tech is sitting in his chair, his attention focused on the hard plastic ear mold he is shaping with a hand-held grinder. Another is polishing an ear mold on a buffing wheel.

And in a little two-room suite near the back of the building, the future is unfolding. That's where **Lanel Menezes '03 M'04**, head of research and development for Microsonic, is working on a technology that will someday change the way the company does business.

From his computer, Menezes rotates a three-dimensional image of an ear mold, manipulating the subtle curves and undulations to make the piece a better fit. Then, with a few clicks, he sends the design to the next room, where lasers zap a vat of crystal clear liquid and the ear mold emerges, complete and ready for final polishing.

Microsonic is developing this new manufacturing approach in conjunction with RMU's Center for Applied Research in Engineering and Science, or CARES. It's a mutually beneficial arrangement: The company taps the University's expertise, and RMU students get the opportunity to tackle a real-world engineering challenge.

To make the project work, Menezes and the CARES engineers had to quickly absorb 40 years' worth of ear mold know-how. Every person's ears and ear canals are unique and constantly changing. "Your ears and nose are the two things that never stop growing," Menezes says.

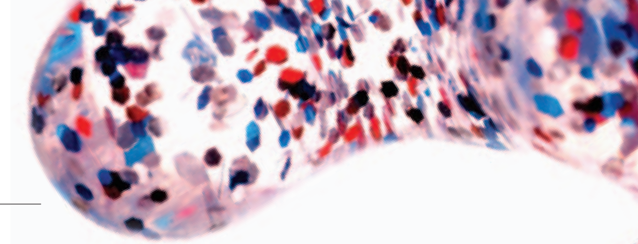
For a proper fit, a hearing aid must be custom-made for the individual who wears it. The ear mold is the portion of the hearing aid that is inserted into the ear canal, holding the hearing aid snugly in place and blocking out extraneous sound. Microsonic's main product is ear molds for hearing aids, although it also manufactures custom ear plugs for swimmers and musicians, as well as earpieces for electronics such as personal music players and the communications earpieces worn by law enforcement officers.

Traditionally, the process of making an ear mold goes like this: A patient visits an ear specialist, or audiologist, and the doctor squirts a clay-like substance into the patient's ear canal. After 10 minutes, the doctor removes the clay, which has hardened into a perfect representation of the person's ear. The doctor then packs it up and ships it to Microsonic.

The little boxes arrive by the dozens at Microsonic, where the impressions are unpacked and placed in little metal trays. A technician inspects the impression; the finished ear mold will only be as good as the impression, so bad impressions have to be retaken. The technician cleans the good impressions and fine-tunes their shape, filling small imperfections with molten wax. Then they are taken to the molding room, where they are grouped into clusters and a cement-like compound is poured over them, leaving a cavity shaped like the original impression. The final ear mold is made from this casting by pouring the melted material into the cast and allowing it to cure.

A technician removes the ear mold from the cast and trims excess material, using scissors, small grinding tools and polishing wheels. Holes are drilled for venting and for the tube that pipes amplified sound into the ear. Finally, the ear mold is tumbled in a polishing machine to smooth it.

While Microsonic has perfected this approach over the decades, the traditional process has its limitations. For one thing, doctors have to mail the impressions to the company. The castings are discarded shortly after the ear molds are finished, so the ear molds can't be replaced. Making some complex shapes is difficult or impossible, because there are



some things that tools just can't do, like drilling a hole that isn't straight. And the intensity of the necessary training makes adding new workers expensive and time-consuming.

It takes six months before a new employee can produce a finished ear mold, Menezes says, because it takes time to develop the manual dexterity and precision required to hand-shape a plastic part half the size of a walnut. There's also a lot to learn about ear anatomy. When Menezes was hired, he recalls, his trainer spread 120 ear molds out in front of him and handed him a single impression. He was required to pick out the ear mold that matched the impression – in less than 10 seconds. Even with this training the process is subject to human variability, Menezes says. For example, at one point impressions are dipped in wax, and the thickness of the wax coating depends on the length of time they remained submerged.

One way to overcome some of these hurdles is through a set of manufacturing technologies first developed for rapid prototyping. Instead of starting with a solid piece of material and cutting, grinding, trimming or molding it into a final part, rapid prototyping machines start with a 3-D model of the finished product and then build it, layer by layer, from powdered or liquid materials.

Rapid prototyping is quickly being adopted by industry as an alternative manufacturing technique, according to **Zbigniew Czajkiewicz, Ph.D.**, head of CARES. "The technology is cheaper for some applications where you're making a limited number of parts," he says, "or when the parts have to be customized and are very intricate."

Microsonic had been looking to add a rapid prototyping division to its arsenal for several years when Menezes graduated from RMU and started his job hunt. As it happened, Menezes' uncle, RMU professor **Joseph Correa, Ph.D.**, belonged to the same YMCA as Microsonic founder Miklos Major. At Correa's request, Major agreed to interview Menezes, who was finishing up his final semester in RMU's Master of Science in Engineering Management program. Menezes also had earned a Bachelor of Science in Engineering at the University and had experience with rapid prototyping and reverse engineering – just what the company was looking for. The company hired him as a research and design engineer.

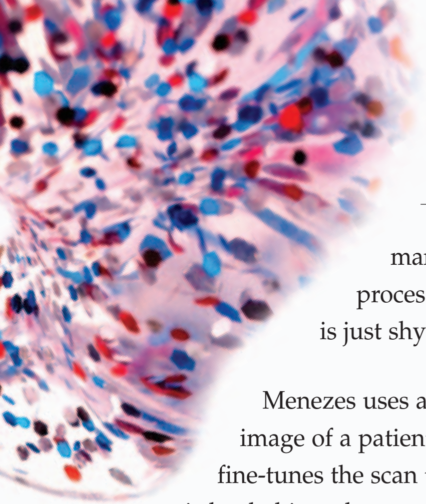
Creating a rapid prototyping process for Microsonic was a series of significant challenges, and Menezes soon enlisted the aid of his former professors. CARES and Menezes divided the research to prevent duplication of effort.

The first difficulty was learning how the computer images translated into a physical product. "A digital representation on the computer screen doesn't do absolute justice to a real-life, physical model," Menezes says. "Since an impression is scanned as a triangulated model, accurate dimensions for curved contours were hard to measure. This led to an intense trial and error period before we could get products that were accurate to a fraction of a millimeter." Although he selected software designed for the ear mold industry, it had to be adapted to Microsonic's designs.

Another challenge was selecting the specific material from which to make the ear molds, says **Ozden Uslu**, a student in the Master of Science in Engineering Management program and the lead CARES researcher for the Microsonic project. The material had to be totally clear and nontoxic. The company already used a dozen different materials for its ear molds, but none of them would work for rapid prototyping. Uslu went through hundreds of materials to find one that met Microsonic's standards.

RMU also helped find funding for the project. Innovation Works, part of the Ben Franklin Foundation, awarded CARES and Microsonic a $40,000 innovation adaptation grant. The program supports small manufacturing companies that are trying to adopt new technologies.

After more than a year of research and testing, Microsonic has started producing ear molds with its new rapid



manufacturing technology. The process, known as stereo lithography, is just shy of wizardry.

Menezes uses a 3-D scanner to create a digital image of a patient's ear impression. He then fine-tunes the scan to create a final design, which is loaded into the stereo lithography machine.

A clear liquid resin is poured into a reservoir in the stereo lithography machine, and a platform, honeycombed with holes, sits just under the surface of the resin. The machine takes the 3-D computer model of the ear mold and translates the image into a series of slices. Then it uses a laser to trace a slice of the ear mold, hardening a small portion of the resin's surface. Then the platform lowers by 0.004 of an inch, and the laser hardens another slice. The ear mold is built slice by slice.

The result is a finished ear mold with a texture that looks like a fingerprint, needing only a final polishing. Designing the ear mold on the computer takes about 10 minutes; the stereo lithography machine can produce a batch of 60 ear molds in about six hours.

Aside from its speed, the new process has several other advantages. The machine isn't encumbered by many of the limitations of hand tools, so Microsonic can create more intricate designs. Previously, any venting or sound holes in the ear molds were bored with a drill, so they had to be straight. The new process can make curved holes that better fit the ear mold's shape. If a patient steps on an ear mold and breaks it, the company can simply build a new one from the customer's 3-D computer file. And down the road, doctors will be able to scan impressions right in their office and transmit the file electronically, eliminating the need to mail impressions back and forth.

While Menezes doesn't foresee rapid prototyping completely replacing Microsonic's traditional manufacturing process anytime soon, he does expect that it will take a larger share in the next few years. He's working on plans to add another stereo lithography machine, hire more technicians and find more materials that will work with the machines. And he's putting together a program to market this new service to Microsonic's clients, starting this spring.

RMU is also looking to expand its investment in this technology. The University is seeking a $250,000 grant from Pennsylvania's Keystone Innovation Zone program to build a rapid prototyping center, which would provide services and training to local companies.

"This is the future of manufacturing," Czajkiewicz says. "In 50 years, we will not have machines that are cutting metal. Everything will be made this way. The applications are endless."

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