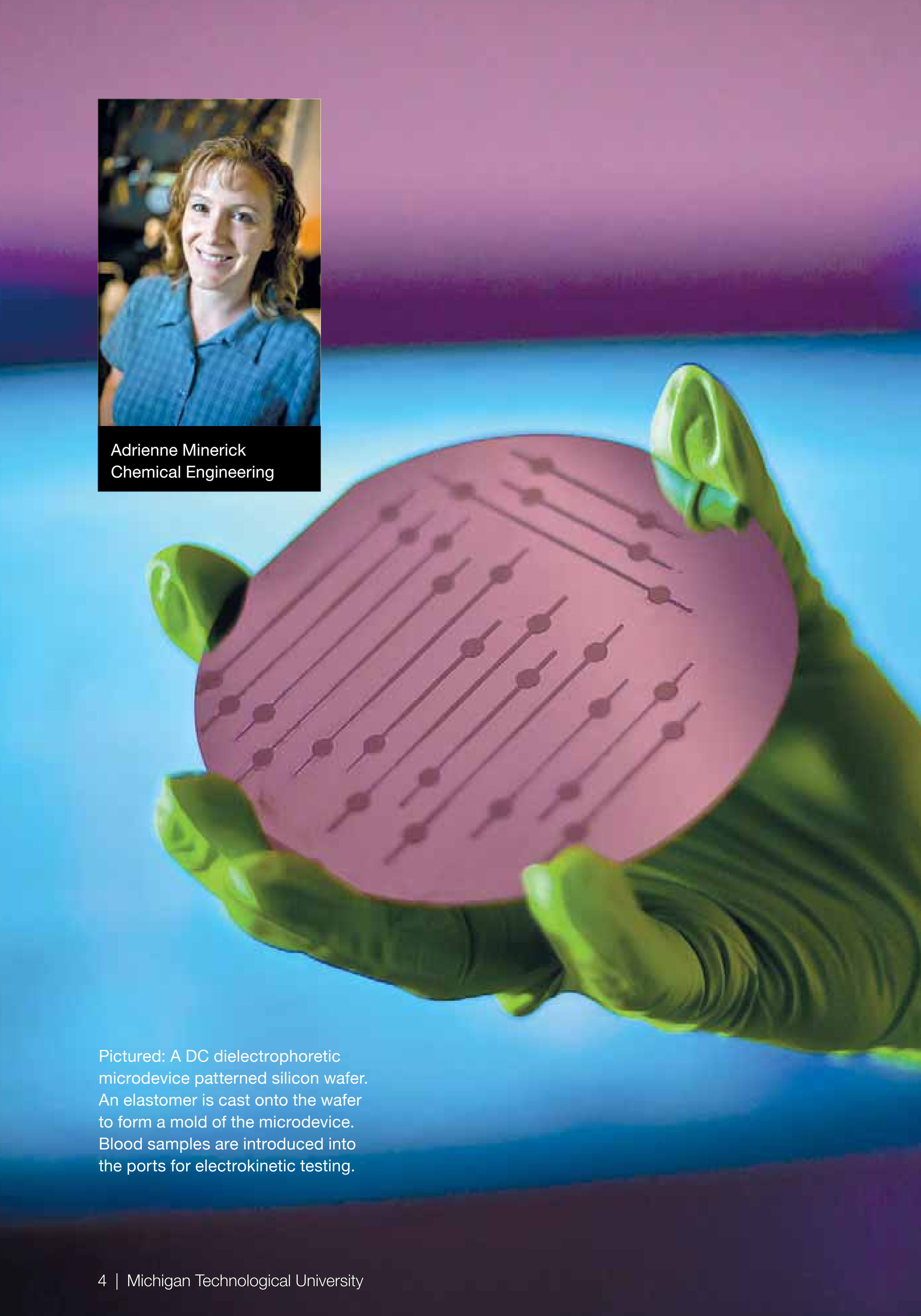

Adrienne Minerick
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Pictured: A DC dielectrophoretic microdevice patterned silicon wafer. An elastomer is cast onto the wafer to form a mold of the microdevice. Blood samples are introduced into the ports for electrokinetic testing.

Medical diagnostics

Detecting blood disorders with point-of-care microdevices

Medical diagnosis often relies on the recognition of an initial symptom followed by expensive and time-consuming laboratory procedures that are outsourced to special analytical laboratories.

Lab-on-a-chip technology has the potential to replace offline lab analysis with point-of-care blood tests that could provide the patient with positive or negative results—along with quantitative information on disease progression—in less than five minutes. This has already been accomplished with blood glucose meters.

Imagine having such technology for common blood chemistry panels, or even for early detection of diseases such as leukemia. Rapid, inexpensive tests requiring very small sample volumes could enable diagnosis much earlier in the progression of a disease, and subsequently provide the potential for preventative treatments.

Adrienne Minerick has been exploring dielectrophoresis—a special nonlinear electrokinetic tool that polarizes cells via non-uniform alternating current (AC) fields. Her research team has discovered that erythrocytes (red blood cells) move up or down the electric field gradient based upon the antigen molecules expressed on the cell membrane surface.

Antigens on erythrocyte membranes determine blood type," Minerick explains. "Due to transfusion compatibility, the most common system is the ABO system where eight blood types (A+, B+, AB+, O+, A-, B-, AB-, and O-) differ by the expression of a combination of three antigens and two antibodies."

Microdevices have fluid channels and chambers whose dimensions are on the order of 10^{-6} meters in size and hold nanoliter sample volumes. Electric fields are commonly employed to move fluids and these same electric fields can be used to characterize and manipulate cells, large molecules, and even ions. Minerick has conducted preliminary dielectrophoretic screening experiments at an AC frequency of 1 MHz in custom-designed microdevices. "The experiments indicate that O+ red blood cells can be distinguished with greater than 95 percent confidence from other blood types. This technology could make portable blood typing devices for use in emergency situations or remote field locations a reality."

Minerick and her research team have also found that by tuning the AC frequency to the kHz range, subcellular diagnostic applications are easily realizable. In this frequency range, erythrocytes from the eight blood types rupture due to field-induced membrane instabilities at slightly different resonant frequencies indicating that molecular expression of antigens influences membrane integrity.

"This phenomena is useful from a diagnostic standpoint," notes Minerick. "As the cells rupture, the interior molecules are released into the surrounding medium and can be analyzed via linear electrophoretic separations and detections. The potential for rapid medical diagnosis is substantial. With a lab-on-a-chip technology, the approach to medical care will likely change from a symptoms-dominated diagnosis to a chemical diagnosis, with rapid treatment and advances in disease management and prevention."